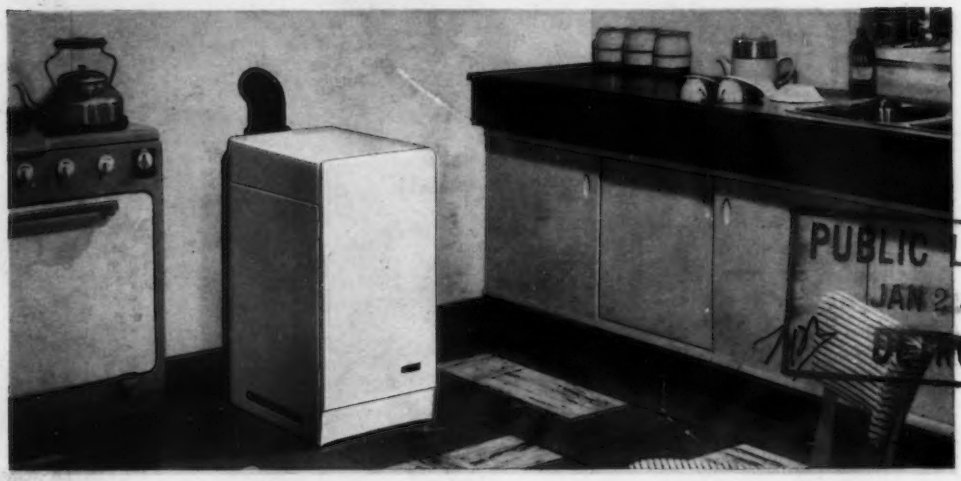
TECHNOLOGY DEPT.

Gas Journal

VOL. 289. 109th YEAR. LONDON, JANUARY 2, 1957. Nº 4877. PRICE 1/6



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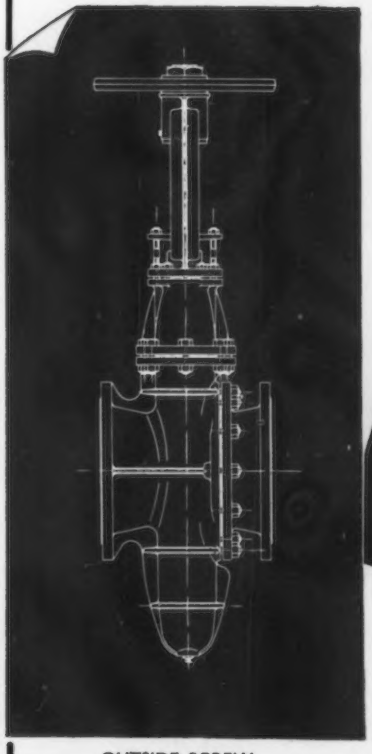

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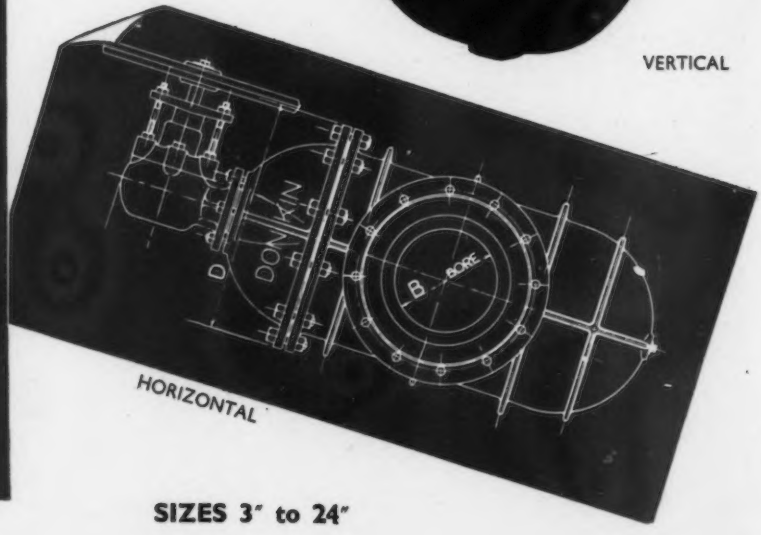

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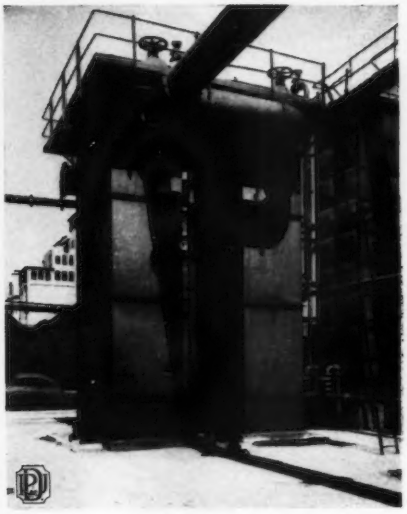

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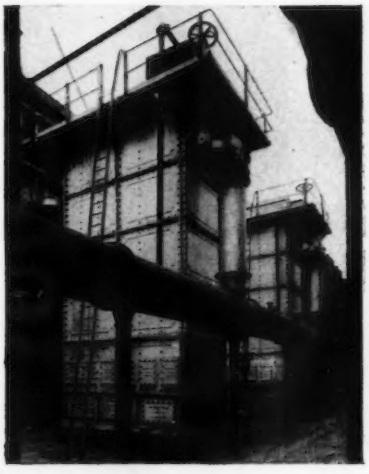

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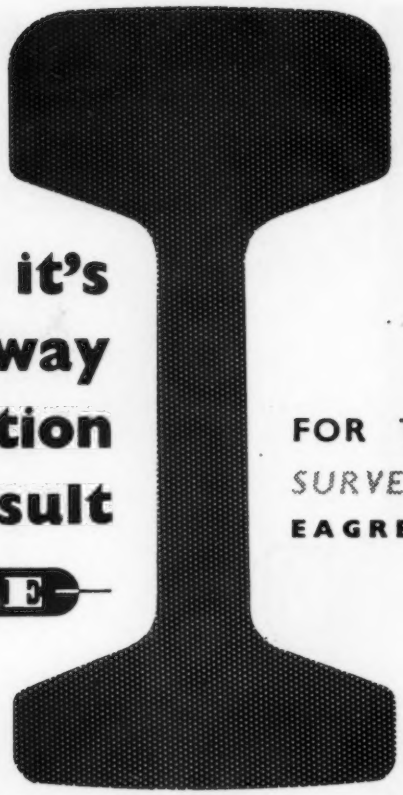

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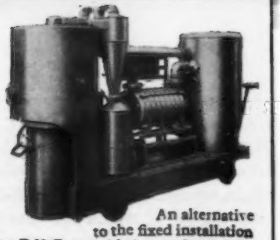

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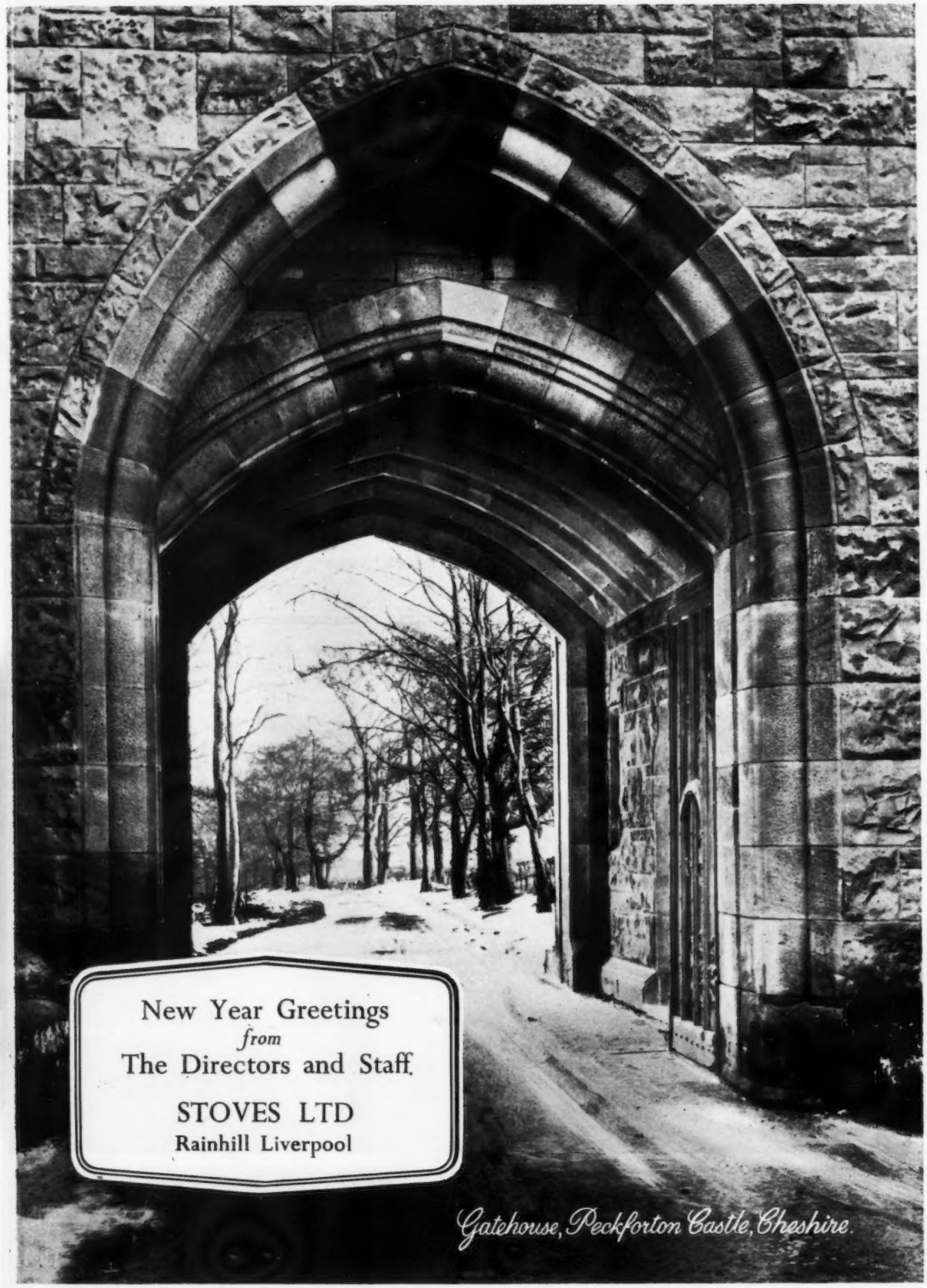
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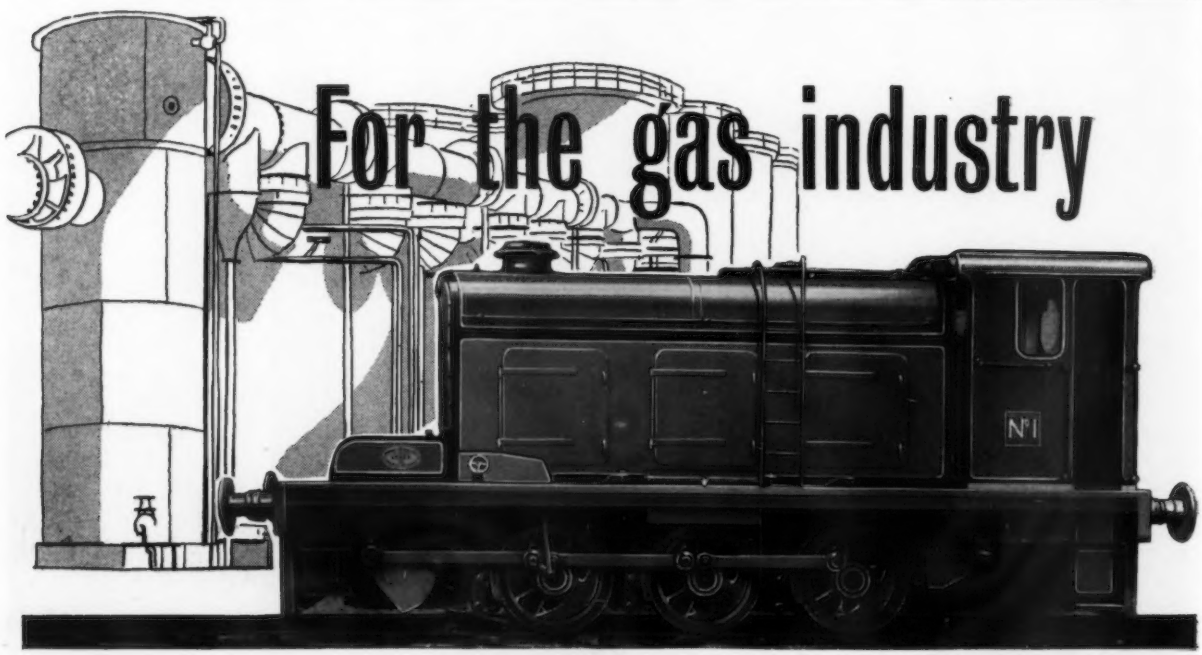

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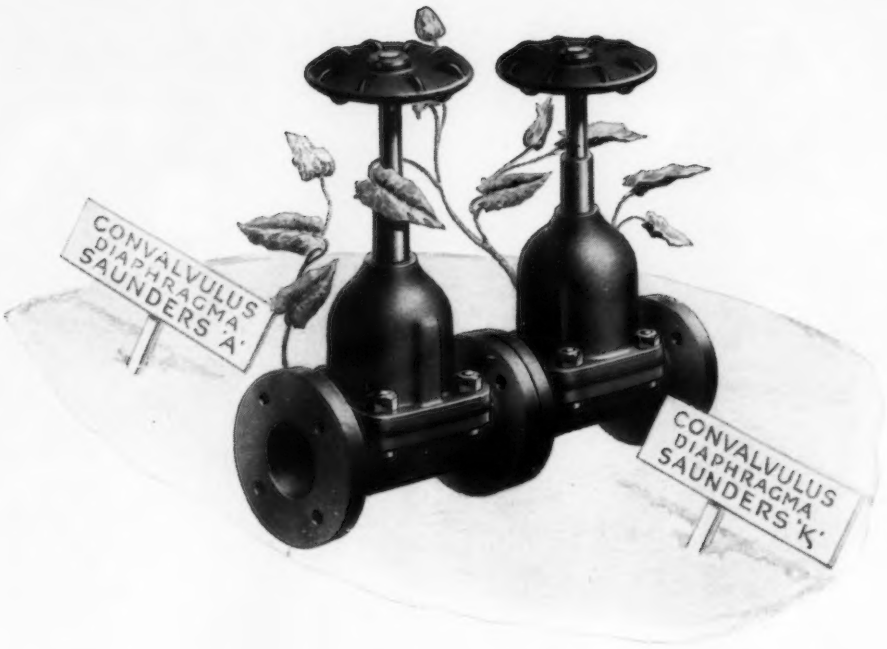

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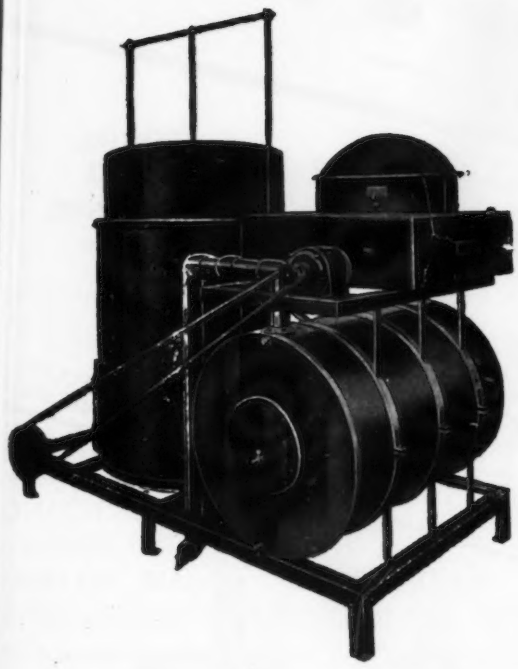

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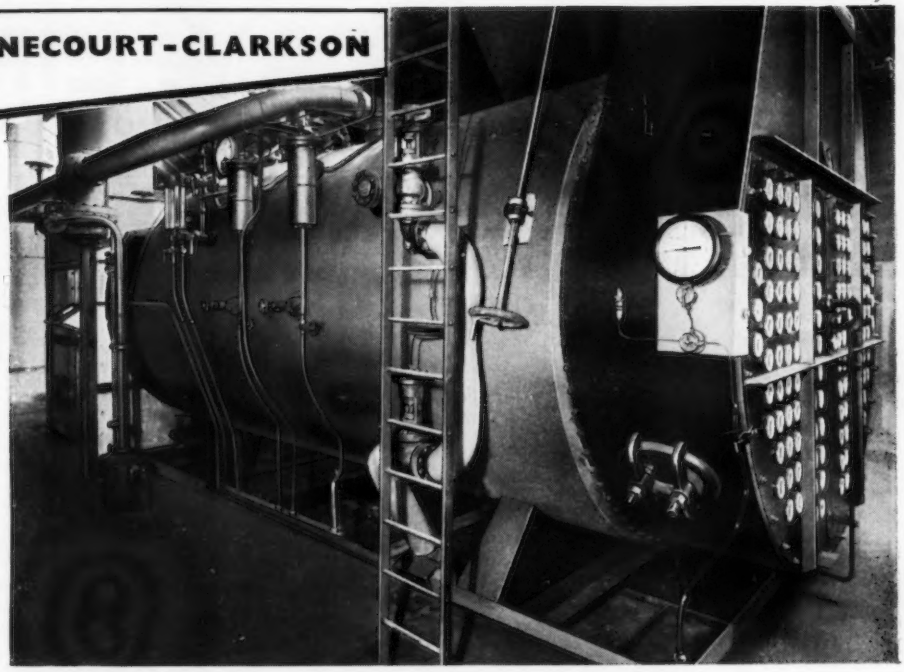

The illustration shows one of the Spencer-Bonecourt waste-heat boilers at Stoke-on-Trent Gas Works. Similar units are installed on all the Glover-West Continuous Vertical carbonising plant in this works.

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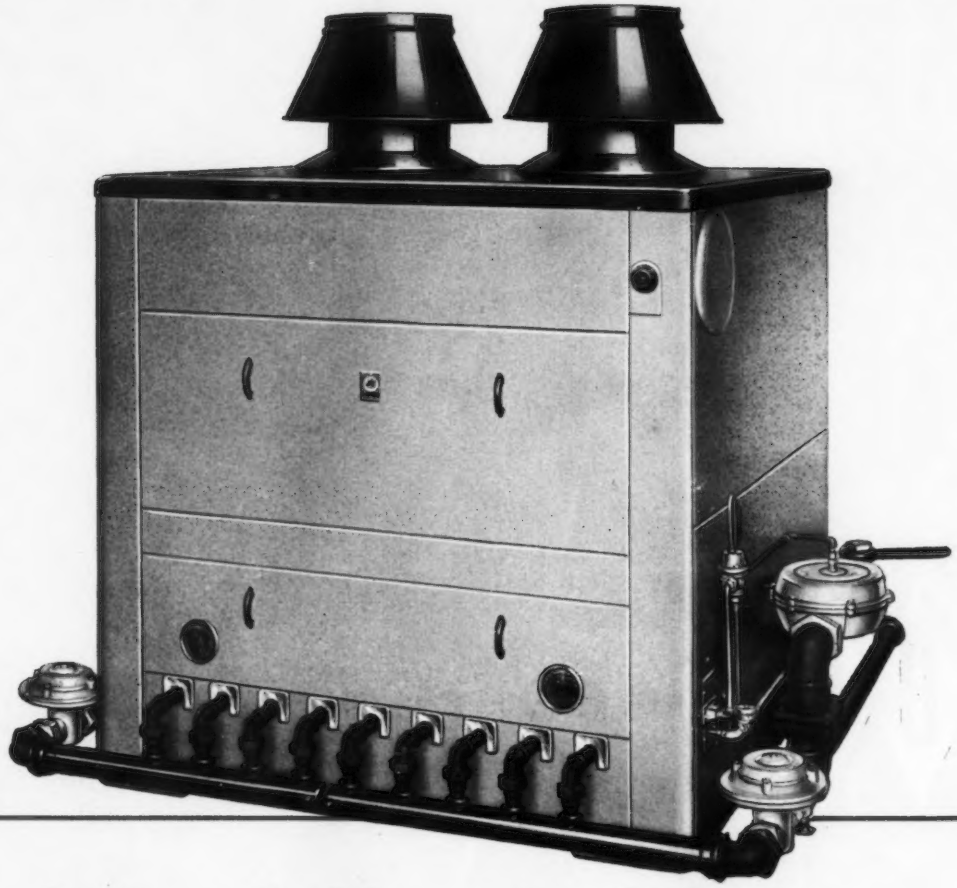

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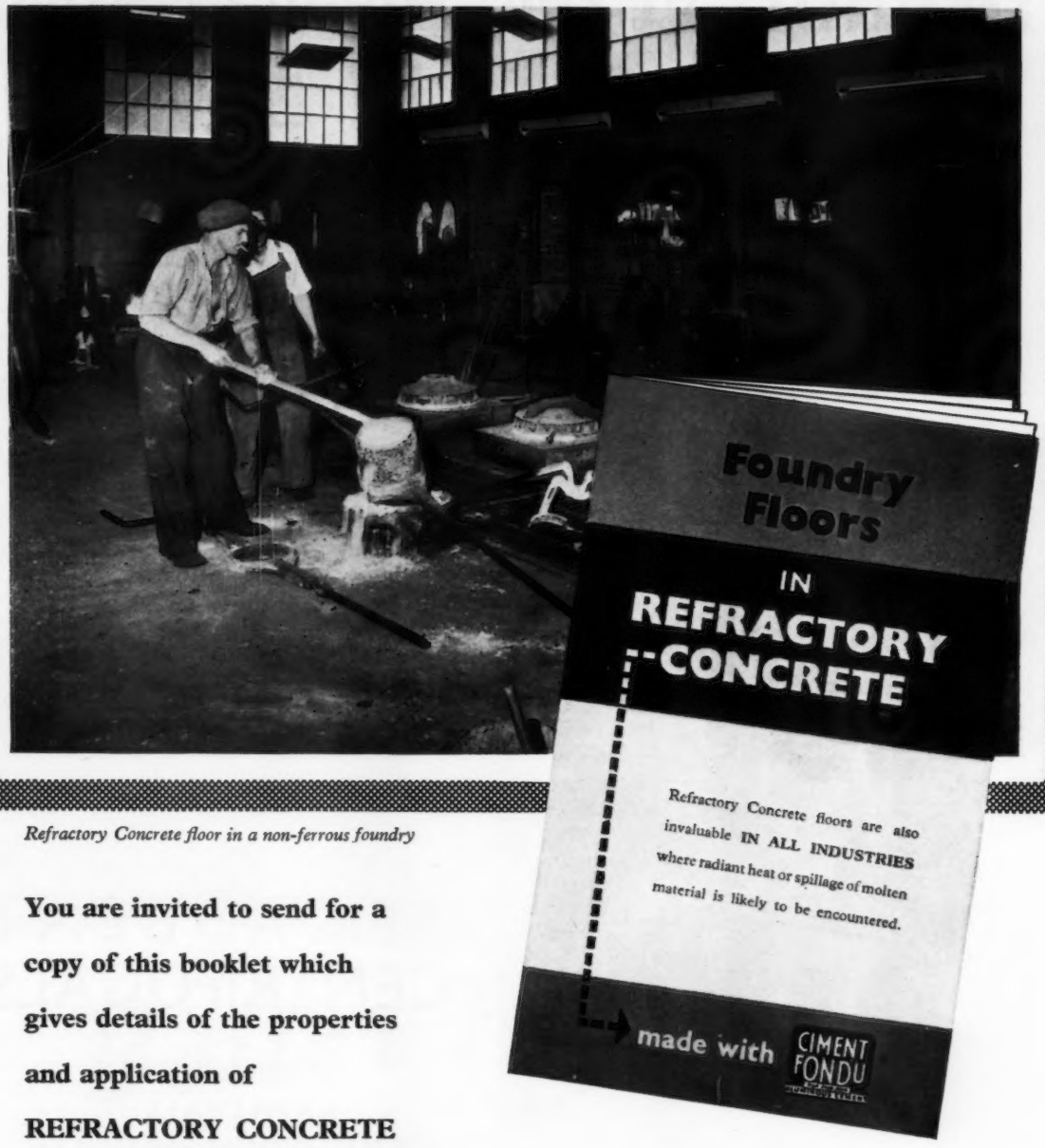
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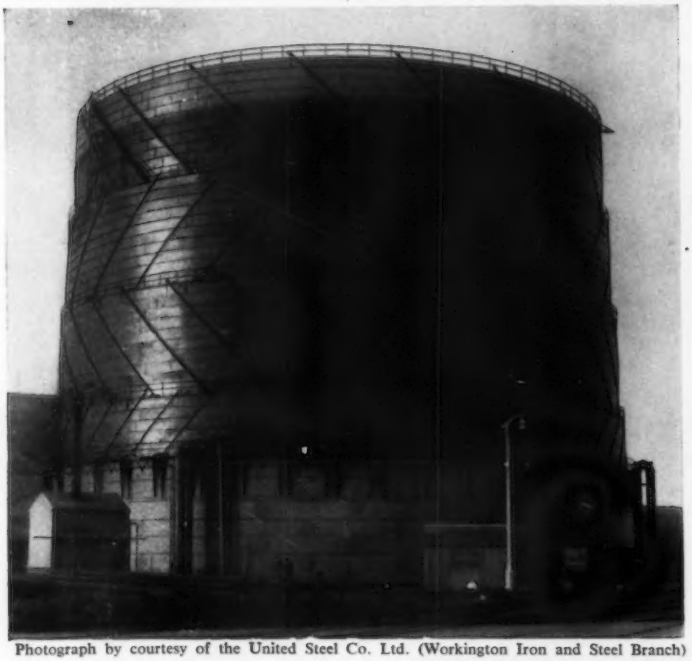

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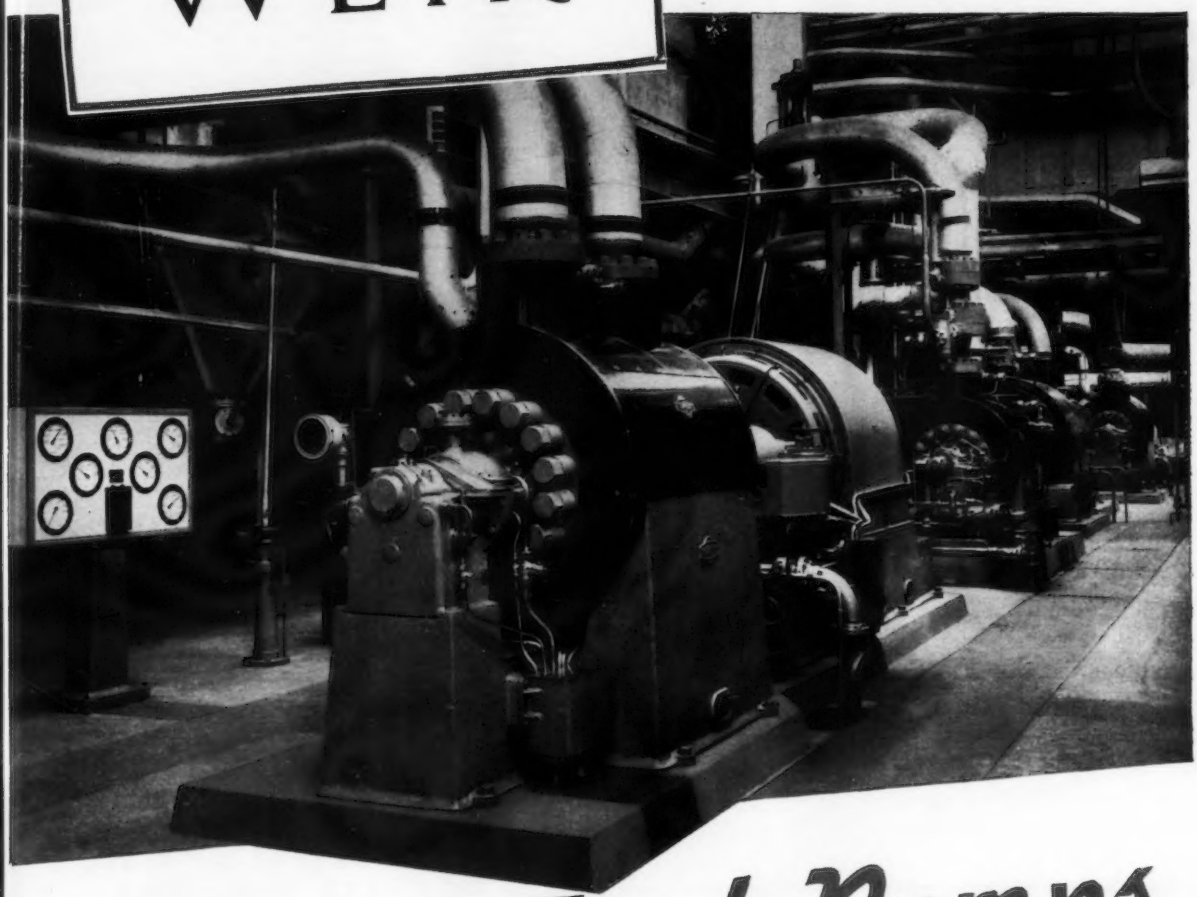

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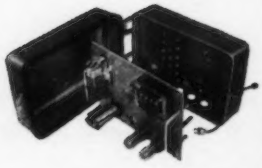

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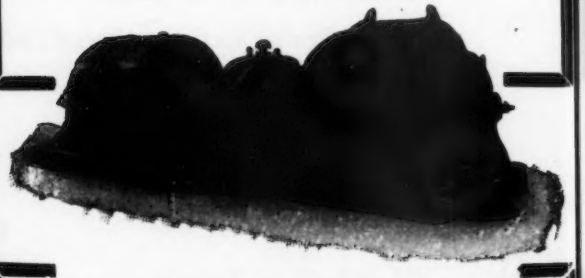

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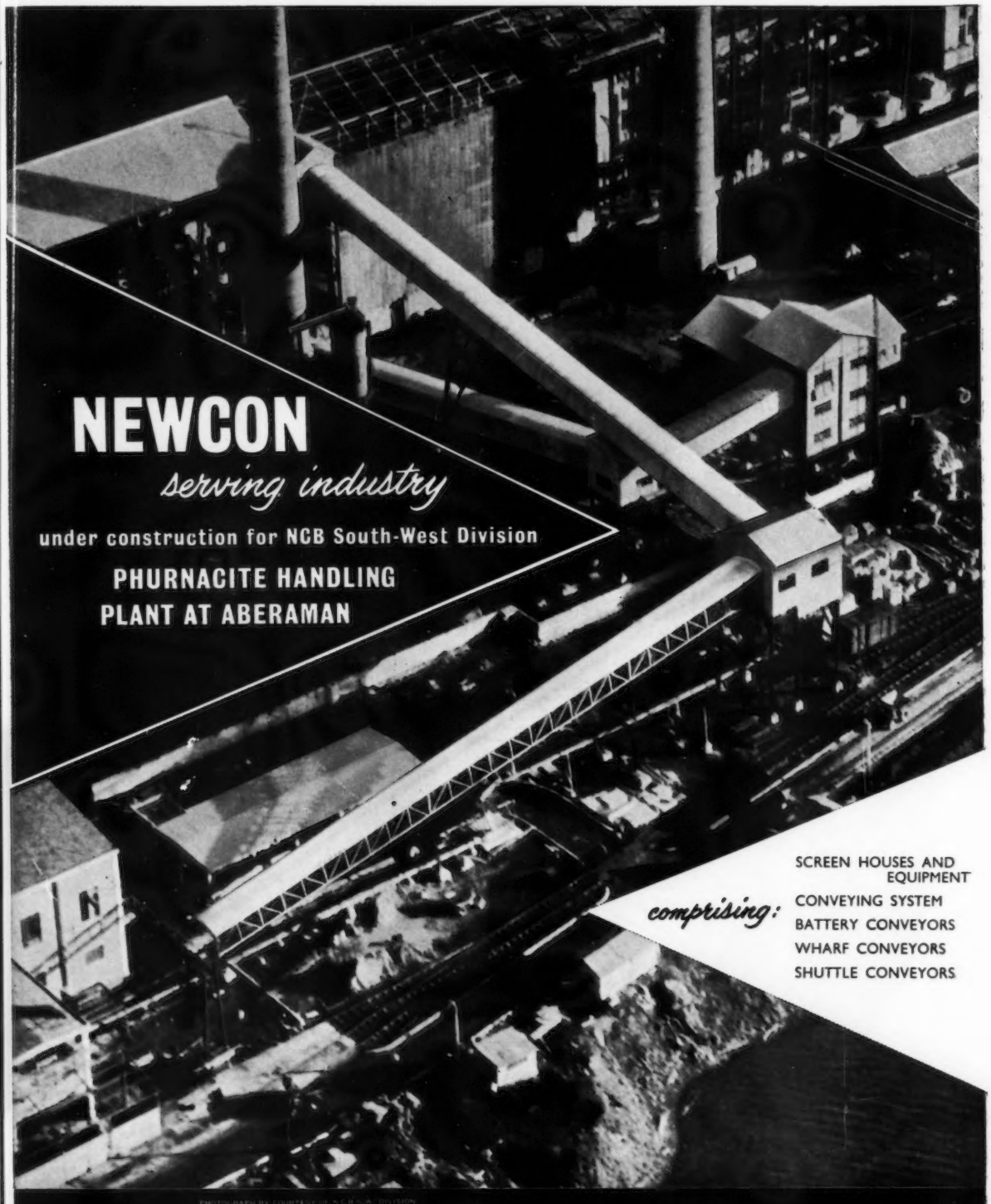

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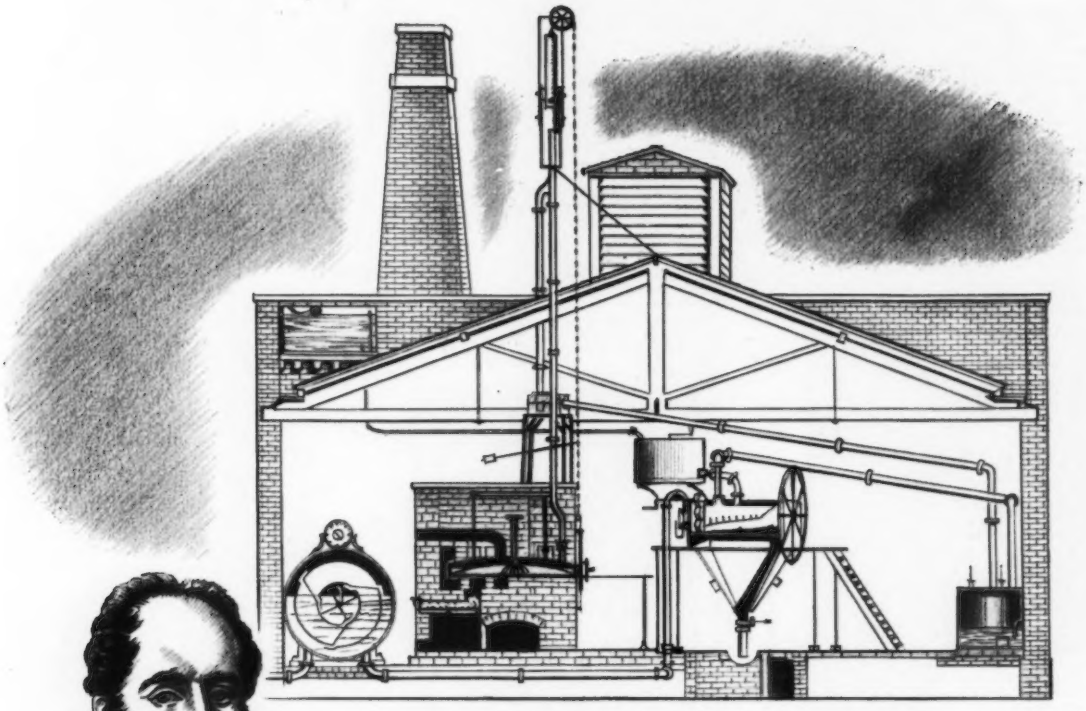

(Above) Gas making Plant at Royal Mint

Samuel Clegg

(1781—1861)

NOW generally recognised as the first Gas Engineer, Samuel Clegg was born in Manchester in 1781. He was apprenticed to Boulton & Watt in 1805 where he had the advantage of working under William Murdoch. Whilst still a pupil he installed a gas lighting plant in Henry Lodge's cotton mill at Sowerby Bridge, near Halifax. Later he introduced the system of purifying gas by lime and in 1811 he installed gas in Stonyhurst college, Lancashire and there used his perfected " lime machine " which was the origin of the type used in the Industry for a further century. In 1813 he was appointed Engineer of the Chartered Company and he carried out extensive improvements to the gas works in Peter Street, Westminster. Two of his most important inventions were the gas meter and self-acting governor.

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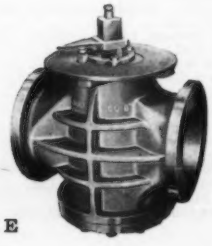

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Gas Journal

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109TH YEAR

MANAGING DIRECTOR: Clifford A. King

EDITOR: Geoffrey W. Battison

TECHNICAL EDITOR: Charles J. P. de Winton, T.D., M.A., M.Inst.Gas E., M.Inst.F.

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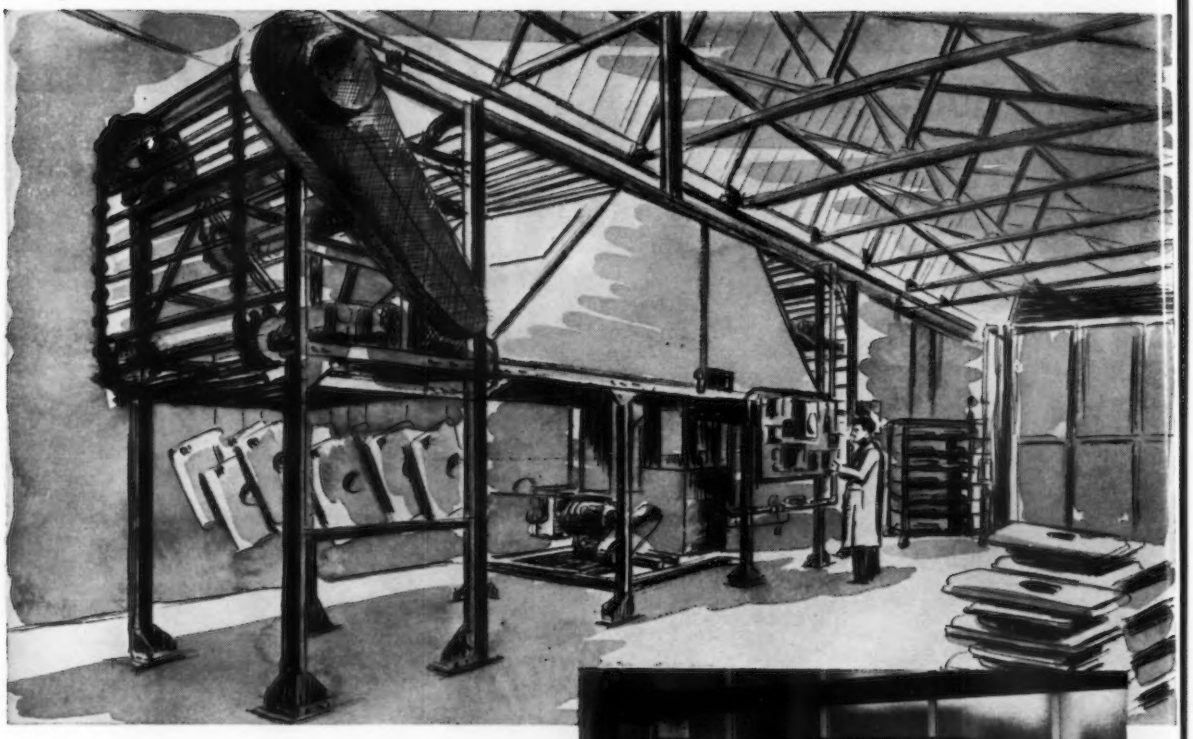

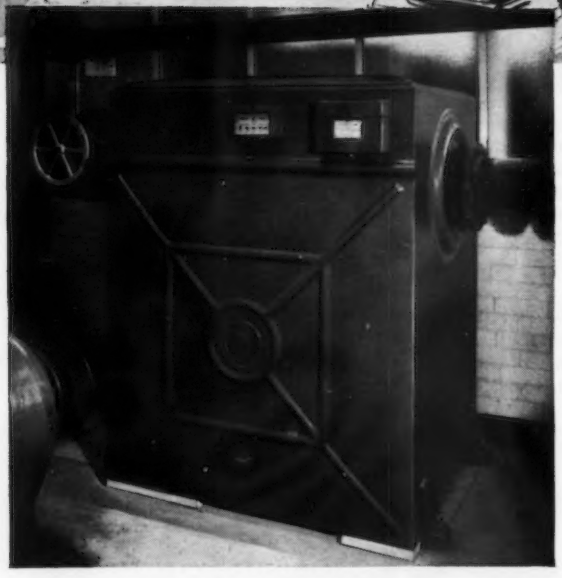

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Gas Journal

VOLUME 289. No. 4877. JANUARY 2, 1957. 109th YEAR

Ten Years of Coal Nationalisation

THE National Coal Board completes the first ten years of its existence on January 1, 1957, and it was with great interest that we studied the pamphlet, *British Coal, the Rebirth of an Industry*, which the N.C.B. has just published to celebrate its first decade.

The coal industry is often the object of a good deal of criticism by those who feel they are being frustrated by a shortage of fuel which they consider vital to the working of their factories or to the warming of their homes and offices; and perhaps we, too, may have been among such people in the past. It was therefore with particular interest that we read this latest publication, in which the N.C.B. have given some idea of the difficulties they had to face at the time of nationalisation, which included inadequate stocks to meet one of the most consistently cold winters of this century. Perhaps it was because the coal mining industry had to face these difficulties at a time of the year when demands for its products were at their greatest, that vesting day for the gas industry took place on May 1, 1949, instead of January 1 of that year.

Facing the prospect of six months' grace before the winter months began to make their demands was indeed a respite for the gas industry.

Inadequate stocks constituted the first difficulty the N.C.B. had to face, but this could be got over in due course, given a breathing space. However, industry had already begun its post-war expansion, and these extra demands had to be met somehow. Factories may be expanded and be fully operative at their newly increased outputs in a matter of two or three years, but the development work needed to get a new colliery into full production may take anything from three to ten years. In that time industrial energy demands must be kept supplied and allowed to expand. The very limited production—if indeed there is any production at all—at new collieries being sunk, or old collieries being 'reconstructed,' make it appear that a great deal of money is being spent for no return at all and certainly with no improvement in coal production. This, of course, is only half the truth, but somewhat difficult for some frustrated large-scale coal consumers to appreciate.

The quality and type of coal being made available by the N.C.B. is often the cause of much criticism, but the Board say this complaint will become less and less as development plans mature.

A great many of the old seams are being worked out and more and more exploration is being carried out with the discovery and bringing into production of new seams. These are probably deeper than the seams in place of which they are being worked, so it is essential that the most up-to-date means of mechanical coal cutting and transportation should be used. The use of the coal cutter which must cut into the rock above and below the new seam, will involve a considerable quantity of non-carbonaceous matter being brought up to the surface with the coal. This will mean that additional cleaning and coal preparation plant is needed. The N.C.B. are well aware of this and have installed 200 new plants which make possible the washing of 60% of the total coal output in Great Britain.

The magnitude of the task which the N.C.B. had to undertake on January 1, 1946, can be imagined if certain facts are borne in mind, facts incidentally which faced the area gas boards on vesting day, too, but on an even larger scale for so large an organisation as the N.C.B., which would eventually be divided into divisions, less independent than the area gas boards. The N.C.B. took over 1,000 individual collieries which had been under the ownership of several hundred colliery companies, some large combines and others smaller concerns, but there was at least one thing common among most of them. During the late 1920's and the 1930's there had been very little incentive for the colliery companies to do more than the minimum of development work. The larger companies owning a

number of collieries had installed mechanical coal cutting machines, and a very limited number of belt conveyors as an experiment to replace the compressed air haulage engines working 'pair and tail' with steel ropeways underground, while the loading was done by hand into oscillating shaker conveyors which fed the coal into the 'tubs' or 'trams' which in turn took the coal to the pit bottom. There was still a great number of ponies employed underground.

At nationalisation the N.C.B. decided to completely mechanise their collieries. The latest types of coal cutters, and the latest transportation methods were to be employed, a large development plan was to be begun without delay, and the most modern methods of mining and coal preparation were to be examined with all speed.

This has involved an enormous amount of administrative, as well as technical and scientific, research work, but it really does seem that the N.C.B. is breaking the back of their problems.

The total saleable output of coal from both deep mined and open cast sources has slightly increased for the 51 weeks of 1956 over the corresponding period of 1955; the deep mined tonnage lost for the same periods has decreased, and distributed stocks are up by about half a million tons.

The success of the N.C.B. affects all of us, especially the gas industry, which still relies on coal as its chief raw material. We must congratulate it on its strenuous efforts in its first decade and give it our best wishes for 1957—may it solve all its outstanding problems.

Multi-storeyed Dwellings

AS a result of the increasing tendency of housing authorities to build blocks of flats many storeys high the problem of flue design has become of greater practical and commercial importance. The gas industry is, of course, vitally interested in all aspects of heat services to such dwellings and it is essential that the provision of individual flues for these heights should be placed on a sound basis. It is equally necessary that attention should be given to shared flue systems since these may prove a determining factor when independent gas appliances are considered in competition with alternative forms of heating in such dwellings. The problem is urgent and it is altogether gratifying to see the way in which it is being tackled by the gas industry and to note the wealth of data which has been accumulated, as exemplified by the extremely valuable papers on the subject by T. T. White and J. B. Carne, of the South Eastern Gas Board, and W. J. Bennett and C. H. Purkis, of the London Research Station of the Gas Council, presented at the research meeting of the Institution of Gas Engineers. These two papers are complementary and were appropriately discussed together at the meeting.

Regarding individual flues, a theoretical treatment has been developed resulting in a chart which enables a ready solution to be obtained of any problem involving the flow and temperature in a flue—for example, the production of flow rate in a flue of given height and cross-sectional area or the prediction of the diameter required to promote a given rate of flow. In regard to shared flues, the advantages in space and labour saving of a shared flue over a multiplicity of individual flues are immediately apparent and the shared flue results in considerable savings in building costs. It is also plain that, properly designed, common flue systems can and do operate satisfactorily.

Both papers are in fact eminently practical and the findings can be applied without misgiving and without delay. A simple flue for the construction of a compact multi-flue stack to serve individual appliances of conventional design has been thoroughly investigated. The other type of flue investigated consists of a vertical duct, open at each end, which serves both for the supply of air for combustion and for the disposal of the products of combustion of a number of various kinds of appliances whose combustion chambers are sealed from the rooms in which they are installed. As a result of the work, reliable prediction can be made of the performance of the systems when installed in blocks of dwellings of up to 150 ft. in height.

The duct with the fitted appliances forms a complete system which is aerodynamically isolated from the rooms which it serves and which functions independently of the wind conditions. The system not only has the advantages attendant on the use of balanced flue appliances but in addition avoids the use of wall-face terminals and permits the installation of appliances in parts of dwellings remote from the outer walls. It is an inherent requirement of the single duct system that appliances must operate satisfactorily with vitiated air. This departure from traditional practice in which appliances are designed and installed to be supplied with clean air necessitated measurements of the tolerance in combustion of the appliances to vitiated air and determination of the degree of vitiation attained in the duct with various combinations of appliances in operation. Again the results of the investigation afford no cause for misgiving, and the papers as a whole constitute an outstanding example of the right approach to a problem which simply had to be solved to enable the full heat services of gas to be entirely acceptable and available in multi-storeyed dwellings.

Three New Atomic Stations

PLANS for the development of atomic power in this country are rapidly taking shape. Last month contracts worth well over £100 mill. were awarded for three commercial atomic power stations, two in England and one in Scotland. This gives reality to the Government's provisional programme which provided for the construction of 12 stations in ten years.

The Central Electricity Authority has asked the Nuclear Power Plant Co., Ltd., to be responsible for the Bradwell project, in Essex, and the A.E.I.—John Thompson Nuclear Energy Co., Ltd., to build a station at Berkeley, Gloucestershire. The General Electric Company have been given a contract for the South of Scotland Electricity Board's atomic power station which it is planned to build at Hunterston, Ayrshire. This is the largest of the three projects, with a total generating capacity of 360,000 kW. The C.E.A.'s stations at Bradwell and Berkeley will feed 300,000 kW and 275,000 kW respectively into the national electricity grid network.

The South of Scotland Electricity Board has stated that the station they were hoping to construct on the Ayrshire coast—they have applied to the Secretary of State for Scotland for consent and for confirmation of an order for the compulsory acquisition of a site—will cost nearly £40 mill. The overall cost per unit generated would be competitive with that of a corresponding coal-fired station.

Personal

NEW YEAR HONOURS

New Year Honours announced yesterday include:

G.C.V.O. SIR HAROLD HARTLEY.

O.B.E. F. G. BREWER, Secretary, Gas Council.

M.B.E. F. S. EVANS, Coke Manager, South Eastern Gas Board; G. F. OLIVER, Deputy Chief Engineer, South Western Gas Board.

B.E.M. W. H. BALL, Birkenhead undertaking, N.W.G.B.; C. CLIMO, Bodmin, S.W.G.B.; A. G. ELLIOTT, S.G.B.; H. EVANS, Newtown, Wales G.B.; R. V. JARVIS, Wolverhampton, W.M.G.B.; J. W. MILLS, Wooler, N.G.B.; F. E. WRIGHT, Loughborough, E.M.G.B.

DR. ALBERT PARKER, C.B.E., Director of Fuel Research in the Department of Scientific and Industrial Research since 1943, retired on December 31, after 28 years' service with the Department. He joined the Department as Assistant Director of Water Pollution Research in 1928 and was Director of Water Pollution Research from 1939 to 1943. He previously held University and industrial appointments. The Council for Scientific and Industrial Research have appointed DR. A. C. MONKHOUSE to be Acting Director of Fuel Research, with effect from January 1. Dr. Monkhouse is at present the Deputy Director of Fuel Research.

SIR HERBERT MERRETT has resigned his position as Chairman and Director of Powell Duffryn Ltd. with effect from December 31, 1956. From the same date, Sir Herbert is also resigning from the Boards of the main subsidiary and associated companies of Powell Duffryn Ltd. SIR HENRY WILSON SMITH, at present Deputy Chairman of the Company, has been appointed Chairman with effect from January 1, 1957.

MR. J. E. BRANDON, who is District Manager, Sheffield No. 1 District, East Midlands Gas Board, is leaving the Board to take up a new appointment with the Scottish Gas Board. In his place the Board have appointed MR. W. E. WHITEN, who is at present Deputy District Manager, Nottingham. Mr. Whiten will take up his new appointment early in the new year.

MR. ROY S. FENTON, who joined Chaseside Engineering Co., Ltd., early this year as Assistant to the General Manager, has now been appointed Home Sales Manager to direct the activities of the Home Sales Division throughout the United Kingdom.

MR. S. W. VICKERY, Managing Director of Ferro Enamels Ltd., has been elected Chairman of the Board of Directors of the newly-formed Vitreous Enamelling Development Council.

At a time when world tension is twanging like a guitar string it is pleasant to find that, no matter what nations may do, individuals from different lands can still get together and enjoy each other's company. Especially when good food forms a point of mutual interest. That is what happened when the International Kitchen Club held its Christmas Party at Murdoch House on December 18. While Dame Vera Laughton Mathews presided over some frightfully English roast turkey and Christmas pud. other Club members tempted us to less familiar fare. It was all very peaceful, the nearest sound to gunfire being Sir Harold pulling a cracker. If armies march on their stomachs, doves certainly fly on them.

Diary

January 4.—LONDON AND SOUTHERN JUNIORS: Meyerstein Theatre, Westminster Hospital Medical School, Horseferry Road, S.W.1. 'Application of Mathematical Techniques to Research Problems in the Gas Industry,' E. Woodcock.

January 5.—EASTERN JUNIORS: Demonstration Theatre, Spalding Showrooms, Station Street, East Midlands Gas Board, 2 p.m. 'Industrial Space Heating,' C. A. Lewis.

January 5. — YORKSHIRE JUNIORS: Strafford Arms Hotel, Bull Ring, Wakefield, 2.30 p.m. 'Gastechnik System of Dry Purification,' P. C. Egan.

Mr. E. J. Boothby (left), President of the Washington Gas Light Company, Washington, D.C., U.S.A., has been elected Chairman of the Board of Trustees of the Institute of Gas Technology. With him are Dr. J. T. Rettaliata (centre), President of Illinois Institute of Technology and of I.G.T., and Dr. Martin A. Elliott, Director of I.G.T.

January 8.—MIDLAND JUNIORS: Staff Mess Room, W.M.G.B., Birmingham District, Council House, Birmingham. 'Some Aspects of Gas Distribution,' B. G. Hawkings.

January 8.—EAST MIDLANDS G.C.C.: The Guildhall, Nottingham, 11.30 a.m.

January 9.—SOUTH WESTERN SECTION, I.G.E.: Meeting cancelled.

January 9.—INCORPORATED PLANT ENGINEERS, LEICESTER BRANCH: Bell Hotel, 6.30 p.m. 'Incentive Schemes for Maintenance Work,' D. J. Winfield.

January 10. — INCORPORATED PLANT ENGINEERS, NORTH EAST BRANCH: Roadway House, Oxford Street, Newcastle-upon-Tyne. 7 p.m. 'Space Heating,' F. W. Watson.

January 11. — SCOTTISH WESTERN JUNIORS: 522, Sauchiehall Street, Glasgow, C.2. 7.15 p.m. 'Ladies' Night.' Paper by Miss S. McDonald.

January 12. — EAST OF SCOTLAND JUNIORS: Dundee. Short Paper Day.

January 15.—INSTITUTION OF CHEMICAL ENGINEERS, NORTH WESTERN BRANCH: The Grosvenor Hotel, Chester. 7 p.m. 'Vacation Training for Chemical Engineers,' A. J. Carter.

January 16.—SOUTH EASTERN G.C.C., Kent County Division: S.E.G.B., King Street, Maidstone. 2.30 p.m.

January 16.—INSTITUTION OF CHEMICAL ENGINEERS, NORTH WESTERN BRANCH: The University, Leeds. 7 p.m. 'Equilibrium Flash Vaporisation of Coal-tar and Coal-tar Fractions,' D. K. H. Briggs and F. Popper.

World Production and Consumption of Nitrogen Continues to Increase

SULPHATE OF AMMONIA FEDERATION REPORT

WHILE during the last nine years the production of sulphate of ammonia has more than doubled, there have been even larger increases in the output of some of the competing forms of nitrogen, the annual report of the British Sulphate of Ammonia Federation, Ltd., reveals.

The world trend of both production and consumption of nitrogen is still upwards and during the year under review consumption rose by a higher percentage than the percentage increase in production. But total production exceeded total consumption.

From July, 1955, the subsidy to farmers on sulphate of ammonia was increased from £3 12s. 0d. to £5 16s. 0d. per ton. This factor combined with favourable weather conditions in both autumn 1955 and spring 1956 had an important influence on nitrogen sales. The 1955 cereal harvest yielded record quantities of corn and crops were taken in nearly ideal conditions. Autumn sowings were on a much heavier scale than in 1954 and the effect could be seen in the demand for spring top dressings.

The policy of increasing home food production to reduce the cost of imports was again emphasised in the 1956 Farm Price Review and the importance of grassland development was recognised by the award of increased Production Grants for 1956-57 and a subsidy for the construction of silos.

There was a record demand for sulphate of ammonia for compounding, and straight sales were higher than for many years. The spate of orders received early in March was so great that it could not be wholly satisfied from current production. Imports of sulphate of ammonia were therefore arranged in March and April and all requirements had been met by the end of May. Total United Kingdom production of sulphate of ammonia in 1955-56 exceeded the requirements of British agriculture.

The increased use of nitrogen on both cereals and grassland in the spring of 1956 gave encouragement to all concerned in the development work in which Imperial Chemical Industries Ltd., has been collaborating for many years with official advisory bodies and a large number of farmers. Work is proceeding along similar lines for 1956-57 and home-produced supplies of nitrogen will be available to meet a further substantial increase in demand.

The total shipments of sulphate of ammonia from the United Kingdom, including those to Eire and the Channel Islands, amounted to 125,224 tons against 308,678 in the previous year.

Steady, if somewhat slow, progress is being made in the production of Grade I salt and the total annual output of the registered by-product Grade I producers is now 143,000 tons, representing rather more than 47% of their total make.

The application of protective resin coatings on a plant scale has increased and a considerable measure of success achieved; the increasing cost and delay in delivery of special alloys has shown the importance of this work in the prevention of erosion.

Western Juniors at Gloucester

SOME 40 members of the Western Junior Association who met at Gloucester on December 5 afterwards visited the factory of Meredith and Drew at Cinderford in the Forest of Dean, which uses 20 mill. cu.ft. of gas a year for biscuit manufacture, and has the largest gas fired tunnel oven in Europe.

After the visit the party returned to Gloucester where Mr. J. Bowler, Industrial Engineer, Bath, presented a paper, 'Increasing Demands—Demands Service.' A discussion, mainly concerned with the need for adequate service and well trained personnel, followed.

Mr. T. W. Jackson, Divisional Manager, Bath and Bristol, said it was a great pleasure to welcome the Juniors, and also underlined the fact that service—mostly free service—was recognised as of prime importance by the Board.

Change of Address

Owing to expansion of business the Birmingham office of Air Control Installations Ltd. has moved to larger premises at Wolverley House, Digbeth, Birmingham 5. Telephone: Midland 5148.

SCHOOL LEAVERS WILL INCREASE

A report by the National Youth Employment Council on the work of the service during the years 1953-56, points out that the number of young persons reaching the age of 15 was at its lowest in 1956 (613,000), but will rise until there will be half as many again in 1962 (930,000).

The council states: 'Assuming that there is little change in the national employment position in the next few years, we are advised that these additional school leavers should be able to find jobs and that there should be no increase in unemployment among young workers.

'It may, however, take longer for young persons to be absorbed into employment upon leaving school and there may be some lengthening of the average period of unemployment on changing jobs.'

N.C.B.'s 200th PLANT STARTS WORK AT CWM

New methods of Cleaning Coal

WHEN the new 400 ton-an-hour preparation plant at Cwm colliery, South Wales, cleaned its first coal recently, it became the 200th plant to be put into operation by the National Coal Board.

These cleaning plants vary in size and the one at Cwm, though large, is not exceptionally so by present standards; the largest, that at Manvers Main in Yorkshire, deals with 1,320 tons an hour.

Many of the new plants use two or even three systems of separating dirt from coal: the dense medium process for cleaning the large coal above 1 in. in size, a jigging system (the most popular form of which is the Baum washer) for the small coals, and froth flotation for the coal less than one-fiftieth of an inch in size.

When the raw coal is easy to clean the Baum washer can treat up to 6 in. in size, but when the coal has a high proportion of middlings (interbanded coal and stone) the larger sizes are dealt with in dense medium separators which make a three-product separation—clean coal, inferior coal or middlings, and discard. The middlings are crushed to release the stone and returned to a Baum washer for further treatment.

In dense medium baths separation is effected by mixing a finely-powdered heavy material with water to provide a liquid with a specific gravity between that of coal and stone. The light coal floats and the heavy stone sinks. In the Baum washers separation is made by pulsating currents of water.

With froth flotation a special oil is mixed with fine coal and water; tiny air bubbles, which attach themselves to the oil-coated particles of coal, are introduced and carried to the surface to be raked off in a froth.

World Power Conference

Among British papers to be given at the sectional meeting of the World Power Conference in Belgrade in June, 1957, are 'Review of Production of Combustible Gas from Low Grade Fuel and Agricultural Wastes' by R. W. Rutherford and F. F. Rixon, the Power-Gas Corporation Ltd.; 'The Utilisation of Weakly-caking Coals in the Production of Metallurgical Coke' by H. Bardgett, fuel research station, Department of Scientific and Industrial Research; and 'Underground Gasification in Great Britain' by C. A. Masterman, Technical Director, Underground Gasification, National Coal Board.

Silica-Graphite Paint

By C. R. AVERILL

This picture shows a section of the paint filling and grinding room at C. R. Averill, Ltd.

THE use of silica-graphite paints for the protection of exposed structural steelwork really needs no introduction, but suffice it to say that the company of which the writer is founder, C. R. Averill Ltd., has been continuously manufacturing this paint for over 35 years, initially as 'Dixon's' silica-graphite paint when we imported the powder from the original manufacturers, the Joseph Dixon Crucible Company of Jersey City, U.S.A., and since 1946 under our own trade name as 'Avarc' silica-graphite paint. During that time, this type of paint has been increasingly used for the protection of bridges, gasholders, condensers, oil and water storage tanks, and all types of structural steelwork such as colliery headgear, smoke stacks, grain elevators, etc. At least two nationalised industries have included silica-graphite paints in their specifications for these services. The reason for this inclusion is due to the long life which this particular paint gives when properly manufactured from a carefully selected silica-graphite pigment and a well-balanced medium.

Unique Atomic Structure

High purity natural graphite is one of the naturally occurring forms of carbon and from its unique atomic structure possesses certain notable properties among which are a remarkable inertness to chemical attack, a soft and unctuous nature which make it the best dry lubricant known, and a characteristic flaky crystalline structure of high metallic lustre. (Synthetic graphite now available as a powder ground from scrap electrodes or surplus Government material is not a flake or foliated graphite and therefore lacks one of the most important features of a natural graphite pigment.)

Natural Graphite

Due to the soft and oily nature of high carbon natural graphite its use as a pigment is not recommended since in the absence of any 'key' or 'tooth,' the resultant paint would have exceptionally high covering power but poor durability owing to the low film thickness. However, some medium carbon graphite ores contain a high percentage of silica as an integral part of the ore, and when expertly ground provide a natural flaky powder which is an ideal pigment for the manufacture of protective paints. This natural addition of silica forms a key, and enables the maximum thickness of paint consistent with good brushability to be applied. Both silica and

Part of the paint mixing room at the Alyn Mills, Caergwrle, Wrexham, premises of C. R. Averill, Ltd.

graphite are chemically inert and thus the mixture is resistant to acid and alkaline attack, is non-poisonous, and does not react with the medium in the ready mixed paint. In addition, no change occurs in the particle size of the pigment during the life of the paint film, a phenomena which does take place with some paint pigments when in close contact with the medium or on exposure to atmospheric conditions. In any paint each tiny particle of pigment is surrounded by a film of oil and if the particle size increases the film is ruptured, or if it decreases a void is formed; in either case premature breakdown results. This cannot happen with an inert pigment such as silica-graphite. In addition, the particles, being of a flaky or foliated nature, overlap and form a very tough and durable film with exceptional resistance to the penetration of water and a greatly reduced tendency to blistering.

Silica and graphite have a low density and this, coupled with the flakiness of the graphite, prevent hard settlement so that it is easy to reconstitute by stirring after long periods of storage. Silica-graphite paints are also of low weight, per gallon, so that compared with some other paints on a weight basis, they have a much higher covering capacity. Conversely for this reason prices should be compared on a volume basis. Silica-graphite powder has a high opacity which gives the paint excellent hiding powers so that no additions or extenders are needed, and properly mixed with a balanced medium makes a paint that dries into a hard leathery film well able to withstand the continued expansion and contraction of the underlying metal surfaces.

Finally, the length of life which silica-graphite paint will give is as long, or longer, than any other paint under the varying conditions met with for the protection of exposed iron and steelwork.

One instance on record proves the excellent protective qualities of this paint. In 1924, in a London industrial area, we re-roofed with galvanised sheets a large lean-to building. First each sheet was chemically treated, and then given one complete coat before erection of our red lead graphite primer, followed on the external surface, after erection, with two coats of our silica-graphite paint, natural colour. This roof has not been repainted since, and a minute inspection of the whole of the surface, after 20 years, only showed slight rusting on the edges of the sheets, and the paint on the main part was still in very good condition.

Graphite packing room, showing discharge of silica-graphite powder from grinding mill.

It should be pointed out that an unpainted galvanised sheet in the London area will rust through within five or six years, and also this case proves that one of the essential things to ensure the life of a good paint is to see that the surfaces are entirely free from rust before any paint is applied.

Committee to Study New Gas Distribution Techniques

THERE is no doubt that the high cost of the distribution of gas has had a restraining influence on the development by the gas industry of its distribution systems. The Committee for Economic Studies, comprising the western European countries, of which the Chairman is Mr. Le Guellec, Chairman of the Administrative Council of Gaz de France, requested the International Gas Union to consider the question in order that the views of the engineers and managers in the various countries might be compared so as to determine the measures that could be recommended to reduce the cost of distribution to the minimum.

The Committee for the Study of New Gas Distribution Techniques was constituted for this purpose. It met on July 27, 1956, at the headquarters of the Association Technique de l'Industrie du Gaz en France, in Paris, under the Chairmanship of Mr. W. K. Hutchison, Chairman of the South Eastern Gas Board and Past President of The Institution of Gas Engineers. Mr. Georges Nerot, President of the Association Technique de l'Industrie du Gaz en France, welcomed the members of the Committee and read a message from Dr. Boselli, President of the International Gas Union, who was prevented from attending the meeting.

The work to be undertaken was divided into four parts:

1. An investigation into the decrease of the cost of distribution by the use of new materials or by new methods of using traditional materials. Reporters: Mr. Meyfroot (Belgium) and Mr. Steinkamp (Netherlands).
2. The preparation of recommendations based on existing standards or codes of practice or requirements made obligatory by current legislation in the various countries. Reporter: Mr. Copp (Great Britain).
3. An investigation of the reduction of the basic price of distribution by modification of the pressure or of the velocity of gas. Reporter: Mr. Renauldon (France).
4. Questions relating to the installation of services, risers, meters (simplification or suppression of certain devices, economic methods of siting, etc. . .). Reporters: Mr. Bertini and Mr. Guella (Italy).

Internal installations are to be excluded from the study.

Interesting accounts were given to the Committee by Mr. Renauldon (France) on the distribution of gas by overhead pipelines, and by Mr. Steinkamp (Netherlands) on the use of plastic materials for pipelines.

It was decided that the next meeting of the Committee would be held in London.

New Grant for Scientific Research

THE Department of Scientific and Industrial Research has agreed to make an annual grant to the National Institute of Industrial Psychology for the next three years toward the cost of its programme of research. The conditions resemble those attached to the grants made by the Department to the Industrial Research Associations in that the grant, up to a maximum of £8,000 a year, is related to the amount of grant earning income in the form of membership subscriptions and special contributions toward the general research programme which the Institute can raise from industry. In view of the importance of human factors in productivity, the Department has in recent years extended its interest to the scientific study of human as well as technical problems; the new grant offers to the Institute the opportunity of developing the collaborative research approach which the experience of the Industrial Research Associations in many industries has demonstrated to be so fruitful.

The Institute was founded in 1921 in order to increase scientific knowledge of the factors bearing on the health, happiness, and effectiveness of people at work. Its activities are of three kinds—the dissemination of information, sponsored research and advisory work, and research on topics of interest to all industry and concerned with the basic problems of people at work. With this new recognition of the value of its work and the prospect of additional support from industry which it offers the Institute is planning a more comprehensive programme of research than has hitherto been possible.

From a paper presented at the 22nd Autumn Research Meeting of The Institution of Gas Engineers in London, November 20 to 21.

Experiments with Shared and Individual Flues for Gas Appliances

By W. J. BENNETT, B.Sc.(Eng.), B.Sc., Assoc.M.Inst.Gas E.
LONDON RESEARCH STATION, THE GAS COUNCIL,

and

C. H. PURKIS, B.A., B.Sc., M.Inst.Gas E., A.M.I.H.V.E.
LONDON RESEARCH STATION, THE GAS COUNCIL.

SINCE the second world war, the necessity for extending the gas industry's knowledge to deal with much longer flues, with the increased likelihood of condensation, has become urgent. Blocks of flats many storeys high have been built or are under construction in many cities in Great Britain today. It is, therefore, of great importance that the provision of individual flues should be put on a sound design basis since extrapolation from existing informatlon is uncertain, and the rectification of error will certainly be costly and may be impracticable. Although satisfactory operation of gas fires attached to flues up to 100 ft. tall has been obtained, it is essential to know under what conditions a system of this height is permissible, and, under favourable conditions, how much higher is it possible to attain before the advent of condensation. The same problem arises at a somewhat lower level with water heaters, with their higher efficiencies and the smaller degree of dilution usually encountered.

It is also of importance that attention should be given to unconventional flue systems, since a multiplicity of individual flues may well create difficulties on grounds of space, cost, and so forth. A successful solution of the flue problem in terms of a shared or common flue may well be a vital factor in the putting forward of heat service schemes in which independent gas appliances are considered in competition with alternative fuels, with central services and with all-electric schemes.

Because the problem is urgent, it seemed proper to present an interim progress report on work carried out to date on this subject, and this and the companion paper*should be regarded in that light. The approach is of necessity a compromise, being partly theoretical and partly practical and empirical. This paper deals with theoretical and experimental work on individaul flues, on the particular form of shared flue known as a branched† flue, and on the U-duct type of common balanced flue. Fig. 1 illustrates the main features of these types of flue in diagrammatic form.

Flow Formula

Regarding individual flues, the theoretical treatment is given fully in the paper. An outline of the approach is given here. The first stage was to express the temperature at any point in a flue in terms of the position of the point and the conditions at the base, thus enabling the density and velocity at that point to be expressed in similar terms. These relationships were then used to obtain expressions for the thermal force and resistance, and equating these quantities led to a flow formula. Substitutions reduced the latter to a more easily manipulated form, which became the basis of a design chart which leads to reliable predictions of flow rates and temperature, provided the thermal transmittance of the material and the fractional resistance of the flue and fittings are known.

The advantages in building construction of a shared flue of some kind over a multiplicity of individual flues are immediately apparent. Not only can there be a substantial saving in space, and in the labour involved in providing supports and making joints, depending upon the number of floors, but appearance is enhanced by reducing the number of terminals, and the structure is strengthened. It is difficult to make any general statement regarding the cost of a shared flue as compared with individual flues, but, in the opinion of some British authorities, a saving of up to £30 per flat may be possible, while in France a saving of between 2% and 5% of the building cost of a flat is anticipated.

The arguments brought forward against the use of common flues are as follows:—

(i) Under certain adverse pressure conditions, the products of combustion from an appliance in one dwelling may enter another via the canopy or draught diverter, instead of rising up the flue and discharging at the terminal.

(ii) Raw gas may enter the main flue from one appliance and be exploded by a spark from another appliance connected to the flue. Flame failure devices can eliminate this possibility.

(iii) Sound, cooking smells and so forth, my be transmitted from one dwelling to another. Also, the interconnection between flats provides an additional fire risk.

Practical Experience

Although comparatively little fundamental work has been reported on shared flues, a considerable amount of practical experience is available, mainly from the Continent of Europe. The following notes summarise the information available at the present time.

No fundamental work on shared flues for gas appliances is known apart from the paper given three years ago to this Institution by the present authors, and the companion paper to this one. A certain amount of information is, however, available from practical experience with actual installations for gas appliances, and it is known that tests on solid-fuel installations are being carried out at the present time by other authorities.

Many years ago, common flues were sometimes used for open fires in tall houses, but this practice was apparently discontinued except for the flueing of solid-fuel wash coppers. Many thousands of such common flues exist in blocks of flats in the Greater London area today, and in a very large number of cases the solid-fuel wash copper has been satisfactorily replaced by a gas wash boiler in accordance with the relevant Code of Practice.

In a few installations, instantaneous gas water heaters have been vented into common flues serving three or four appliances. So far as is known, the design of these flues was not based upon any experimental studies, and their performance in practice has in one or two cases been adversely affected by poor termination. Nevertheless, they have given satisfaction for 20 years, and there seems no reason to doubt that, if the terminations had been satisfactory, the flues would have been equally so.

The Building Research Station and the London County

* I.G.E. Comm. 496.

† In view of claims made by the Shunt Company for the use of the word 'shunt', the Authors have followed Barr in referring in the general sense to 'branched' flues.

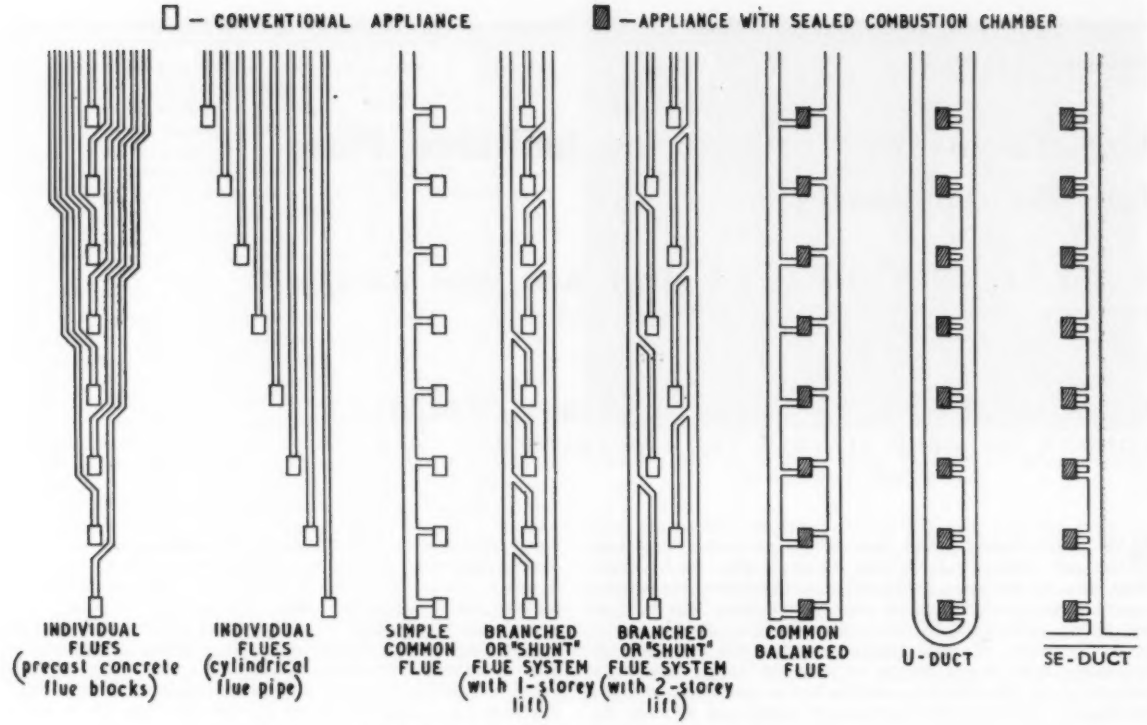
□ — CONVENTIONAL APPLIANCE
▨ —APPLIANCE WITH SEALED COMBUSTION CHAMBER
INDIVIDUAL FLUES (precast concrete flue blocks)
INDIVIDUAL FLUES (cylindrical flue pipe)
SIMPLE COMMON FLUE
BRANCHED OR "SHUNT" FLUE SYSTEM (with 1-storey lift)
BRANCHED OR "SHUNT" FLUE SYSTEM (with 2-storey lift)
COMMON BALANCED FLUE
U-DUCT
SE-DUCT

Fig. 1.—Diagrammatic layout of flue systems.

Council are taking a leading part in studying the possibilities of 'shunt' flues for solid-fuel appliances in this country. Installations at Peckham and at Picton Street, Camberwell, have been the subject of experimental work and of cost studies.

The recent construction and operation of a branched-flue installation for instantaneous gas water heaters is described later in this paper.

The legal position in this country is that such matters are normally regulated by councils or local authorities through building by-laws. The 1953 Model By-laws prohibit the use of shared flues, as do the 1952 London Building By-laws. The installation of gas appliances on the areas of the North Thames and of the South Eastern Gas Boards is also affected by the London Gas Regulations, which in general forbid the construction of shared flues for venting gas appliances. It was necessary to obtain a waiver of the Regulations in order to carry out part of the work described in this paper.

Shared flues of various types have been permitted by regulations or tacitly accepted by the appropriate authorities in a number of European countries, and in the United States of America, and a very large number of such flues have been constructed. Experience in Belgium, France and Holland is largely based upon the 'shunt' flue, developed by the Shunt Flue Company of Brussels.

In Austria, the 'Thermophor' collective chimney has been used to a limited extent, and regulations governing the construction and use of such chimneys were laid down in 1930 and amended in 1932. The 'Thermophor' chimney, which can be used either for solid-fuel or for gas appliances, resembles the simple common flue rather than the branched or 'shunt' flue in that no subsidiary flues are called for (though flues from appliances on the same floor must enter at different levels). Both this and the San Francisco installation referred to later do not employ a parallel flue, but one increasing in size at intervals as it proceeds upwards through the building, in order to accommodate the appliances on each succeeding floor.

In Belgium, although regulations do not officially permit the construction and use of shared flues, some 17,000 'shunt' flues have, in fact, been erected since 1935, largely for use with solid fuel burned in openable stoves. Enquiries concerning the performance of these flues have been made by a number of observers who conclude that, in general, they operate perfectly satisfactorily, that prolonged downdraught is unknown, and that occasional puffs of smoke are blown back on the upper floors only. There seems little doubt that performance is superior to that of individual flues, and the fire services in Brussels know of no accident of any kind with them.

In France, a test installation in Toulon, using both solid fuel and gas appliances, has been the subject of experimental study, and the results have been reported. As a result of these experiments, and of independent enquiries in Belgium and Holland, the regulations were modified firstly to permit the use of 'shunt' flues with solid fuel under certain clearly defined conditions, and subsequently to permit their use with gas appliances.

In Germany, simple common flues for gas water heaters have been in use for many years. Detailed tables governing the design of such flues up to about 50 ft. in height were published by at least one maker of instantaneous gas water heaters in 1930, and their recommendations have now been extended to buildings 14 storeys high. A draft addendum to the Regulations of the Deutsche Verein von Gas and Wasserfachmannern lays down the conditions under which such flues may be used today. In general, the number of heaters that may be connected to a common flue is limited to four, and it is necessary to have a considerable length of flue above the point of entry of the highest heater. The use of branched flues has also been considered.

In Holland, a considerable number of 'shunt' flues are in use mainly, if not exclusively, with solid-fuel appliances. The T.N.O. carried out a series of tests in which 'shunt' flues were compared with conventional chimneys in adjacent blocks, and the superiority of the 'shunt' flue was demonstrated, although an initial lift of more than one storey appeared desirable. These tests were followed by a field enquiry amongst flat-dwellers using the two types of flue, which gave results in general agreement with the tests, the percentage of complaints being 24.8 with conventional flues and only 9.6 with 'shunt' flues. Earlier work carried out in Holland was concerned with the possibility of explosions in 'shunt' flues to which gas appliances were connected. It was found difficult to produce an explosion even under abnormal conditions, and, when an explosion was ultimately achieved, it did little damage.

In the course of a recent visit by members of the British gas industry to the Continent, to study flue installation of

his kind, the general impression was that the 'shunt' flue in conjunction with closed stoves burning solid fuel was proving very satisfactory, while the common flue with instantaneous gas water heaters was equally trouble-free. Both types of flue were being incorporated in considerable numbers in blocks of flats up to 14 storeys high.

Little information is available concerning the use of shared flues in the United States of America, but a branched-flue installation in San Francisco serves gas-fired air heaters with apparent success. This installation is of particular interest since the number of heaters connected to one main shaft is not limited to four or five, as in general Continental practice, but all seven heaters are connected into one shaft, the size of which increases at intervals with the number of heaters venting into it.

Summarising, there is an evident diversity, both in the conditions of use of shared flues and in the official attitude towards them. The simple common flue is forbidden in many countries, but is being used in some of the most modern buildings in Germany today for instantaneous gas water heaters, whilst many thousands of such flues in Great Britain are functioning satisfactorily for gas and solid-fuel wash coppers. Some 40,000 'shunt' flues are operating successfully in Belgium, France and Holland, but are officially permitted only in France and some Dutch cities. Only one appliance may be connected at any one level, with a maximum of five in all. The Austrian 'Thermophor' chimney, which is permitted by regulations, has some properties similar to the common flue but increases in size as the number of connected appliances increases. The only known American branched-flue installation also increases in size as appliances are connected into it, but these have individual branches before entering the main flue; unlike Continental practice, seven appliances are connected to the one flue. It is clear that more fundamental work on the properties of shared flues requires to be carried out in order to clarify present anomalies, but it must be admitted that there is a wealth of field experience available confirming that these systems can function satisfactorily in practice.

Performance Predictable

From laboratory experiments it seemed that the performance of a given branched-flue system could be predicted with a high degree of reliability, provided the ambient pressure conditions were known. The pressure difference between room and terminal is affected by the opening and shutting of doors and windows, the presence or otherwise of neighbouring buildings, as well as the direction and velocity of the prevailing wind. However, for design purposes some basic pressure assumption must be made to cover all conditions, and it must be such that, when used in the equations, it leads to an installation that will give satisfactory performance for a very large proportion of the time, if not for all of it. The decision as to what basic conditions should be assumed must ultimately be arrived at from observations on experimental district installations where and when they are erected. In the meantime, it is suggested that, following Continental practice, the termination should be freely exposed and completed by an extractor-type terminal. This, together with a design assumption of zero pressure differences between the rooms and terminal, which is the normal supposition in the case of conventional flues, should lead to a satisfactory installation. When an opportunity arose at Abbey Orchard Street, Westminster, to erect a branched-flue installation, steps were taken to provide sufficient instrumentation to enable pressure records to be made.

The flues were erected in a block of Peabody Trust flats that were in the process of being converted in order to provide added amenities for the tenants. Among the improvements was the provision of a bathroom in each flat and also a gas-operated bath water heater. The venting of these appliances by conventional means presented a number of difficulties, due to the situation of the heaters, and it was therefore decided, with the collaboration of the architect concerned and of the Headquarters Division of the North Thames Gas Board, to install a branched system.

The complete installation (Fig. 2) consisted of two branched-flue systems side by side. One system vented three appliances, and the other four; structural considerations prevented the fourth appliance being vented into the system on one side. The top-floor appliances were each flued separately. Due to

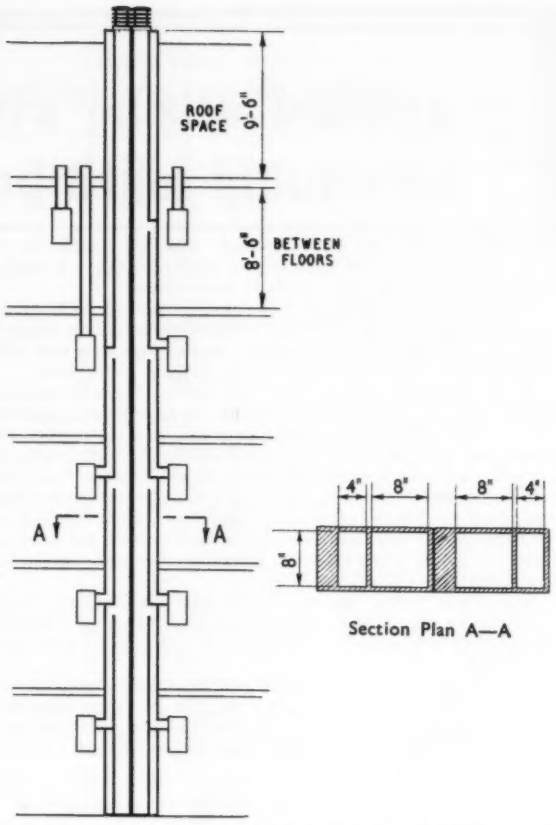

Fig. 2.—Diagrammatic layout of branched-flue installation at Abbey Orchard Street, London.

building difficulties, the main flue shafts were not vertical for the whole height, but contained two offsets, which are not shown in the diagram. The flues were constructed of aluminous cement blocks with an 8 in. square main section and a 4 in. by 8 in. branch. The flues were completed with the latest type 'shunt' terminal, the moulds for which were specially imported from Belgium for this purpose. The appliances entered the branches *via* a 90° bend running from the top of the draught diverter to the appropriate flue block. The whole system was provided with a breeze block casing.

Obtaining Pressure Readings

For the purpose of obtaining the necessary pressure readings, five copper tubes were fitted so that one extremity lay flush with the inside wall surface of each of the subsidiary flues of the four-branch system, while the fifth was situated in the main flue just below the terminal. The tubes were taken down, in between the flue blocks and the breeze casing, to a point on the ground floor. An Arkon pressure instrument, fitted here, enabled a record of the pressures at any of the five points to be obtained.

The work consisted of two phases—a brief 'unoccupied' period followed by normal occupation by the tenants. In the former case, the work consisted of checking that the systems operated satisfactorily and of making preliminary pressure measurements in order to facilitate the interpretation of work in the 'occupied' period. In the latter case, the activities were confined to pressure recordings.

In checking for satisfactory operation, measurements of secondary flue gas carbon dioxide concentrations were made with various combinations of appliances alight, together with tests for spillage. Flow rates obtained from the carbon dioxide measurements were compared with values predicted in accordance with theory and the foregoing pressure assumptions. Table 1 gives the corresponding values.

TABLE I.

Subsidiary Flue	Flow Rate at 60°F. (cu. ft./hr.)			
	One Heater Alight Only		All Four Heaters Alight	
	Expt.	Calc.	Expt.	Calc.
1 (bottom)	2,300	2,200	2,800	2,500
2	2,700	2,100	2,500	2,300
3	1,800	1,900	1,800	2,100
4 (top)	2,100	1,800	2,000	1,800

It can be seen that the agreement with the prediction is good. In addition, the spillage tests indicated that all appliances were clearing their products satisfactorily.

Pressure records during the 'occupied' phase are continuing, and, although any hard and fast conclusions would be premature, the evidence over a 10-week period indicates that the installation is operating satisfactorily without downblow.

In the discussion arising from the authors' communications dealing with the common balanced-flue system, Dick suggested that a neater arrangement would be provided if the appliances drew their combustion air from and discharged their products into the same limb of a sufficiently large U-duct. Such an installation has since been erected in which five water heating appliances with sealed combustion chambers were connected to one limb of an 8 in. dia. asbestos cement U-duct, the heaters being spaced at intervals of 8 ft. up the flue and the limbs completed with G.L.C. terminals.

Since flues of this size proved adequate for a similar heat input in the case of the common balanced flue, this diameter was used so that a ready comparison would exist between the two systems.

In one respect, the results were disappointing, it being found that, even when only four heaters were in operation together, the combustion performance was unsatisfactory, despite the fact that the flow rate, through the system appeared to be adequate. The installation was, therefore, inferior to a common balance-flue systems of comparable dimensions.

Following the practice of comparing experimental and predicted flow rates, expected values were obtained from the chart previously referred to, which proved suitable for this purpose, and compared with measured quantities. The results are shown in Table 2.

TABLE II.

Appliances Alight	Flow Rate at 60°F. (cu. ft./hr.)	
	Experimental (Mean)	Predicted
A (Bottom)	8,350	7,850
B	7,550	7,600
C	5,750	6,650
D	5,200	6,200
E (Top)	5,200	5,250
ABCD	11,300	11,100
ABC	10,150	10,400
CDE	10,000	9,300

* Gas Council Res. Comm. G.C.13.

It can be seen that good agreement was obtained between the corresponding values.

Although not completely successful, the system seems sufficiently promising to justify further tests. An investigation of the carbon dioxide distribution in the main flue showed it to be more concentrated on the near side, so that products from one heater were being fed into the inlet of the appliance above, with relatively little dilution, leading to poor combustion. It seems likely that this may be overcome by the correct relative positioning of the inlet and outlet ducts, or by the introduction of reflector plates.

A main flue of larger size would, without doubt, improve the performance with the water heaters, but it seems likely that the substitution of space heaters would make the increase unnecessary. It is intended to carry out further work along these lines.

From a paper presented to the 22nd Autumn Research Meeting of The Institution of Gas Engineers in London, November 20–21.

Observations on the Performance of a Multi-Flue System and of a Single Duct for Appliances with Room-Sealed Combustion Chambers

By J. B. CARNE, B.Sc.

ASSISTANT CHIEF PHYSICIST, CENTRAL LABORATORIES, SOUTH EASTERN GAS BOARD,

and

T. T. WHITE, B.Sc., A.R.C.S.

SENIOR PHYSICIST, CENTRAL LABORATORIES, SOUTH EASTERN GAS BOARD.

IN this paper, the construction of a system of individual flues using a new form of flue block containing two channels is described. Experimental observations on a laboratory installation are given, and the theory of a flue system based on energy distribution has been applied to the results obtained. The use of the total head pressure is suggested as a means of determining the flow resistances of a flue. The data are used with flow formulæ developed to predict the performance of tall flues.

A new system for use with gas appliances having room-sealed combustion chambers, devised particularly for multi-storey dwellings, is also described. This system, which has been given the name 'Se-Duct,' consists essentially of a single duct open at both ends and passing vertically through the dwellings. Appliances such as water heaters, space heaters and drying cabinets are designed and fitted to the duct so that their combustion chambers are sealed from the rooms in which they are installed. The duct serves to supply both the air for combustion and to dispose of products of combustion. The observed performance of the appliances with vitiated air and the degree of vitiation attained in two experimental installations 50 ft. high are given, with some observations on the behaviour of the system under conditions of inversion. Special design features of appliances for the system are mentioned, and the merits of the system are discussed. A method of calculating the size of a duct of a given height and serving a given number of appliances is proposed using a limited degree of vitiation as the basic criterion.

The system of twin-channel blocks was devised to meet the

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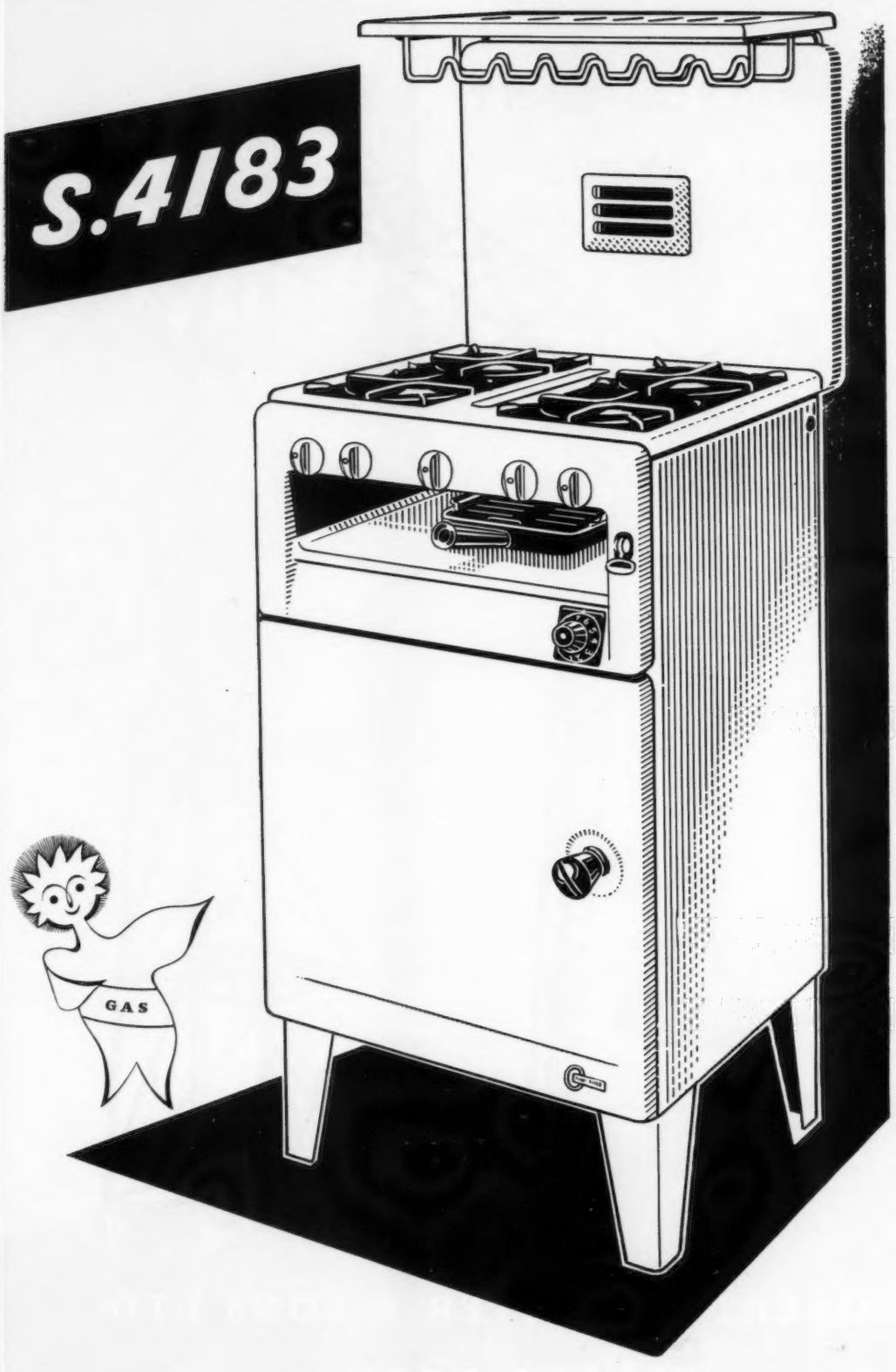

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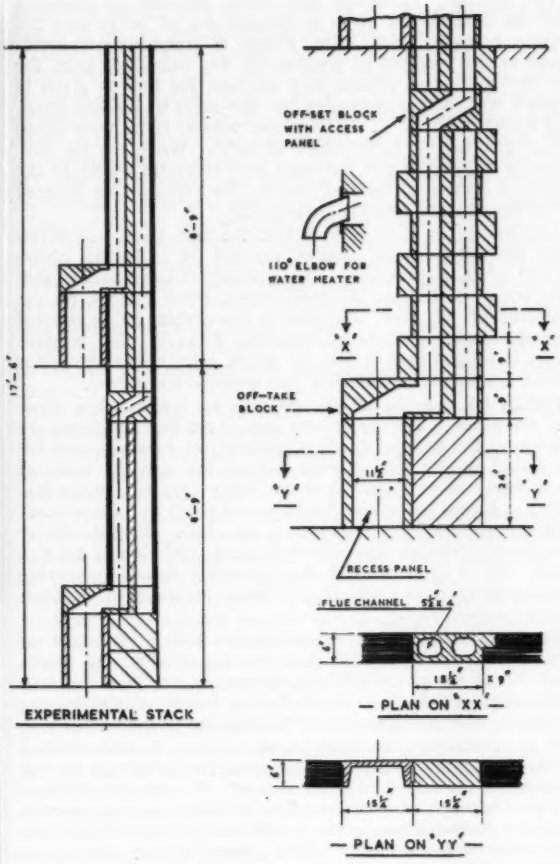

Fig. 1.—Twin-channel block flue.

need for a compact multi-flue stack which could be incorporated in the partition walls of a block of flats for flueing circulator-type water heaters of medium rating.

It was thought that, by making the cross-section of the channels oval in shape and 20 sq. in. in area, the flueways formed would have a flow resistance not appreciably greater than that of a 5 in. dia. pipe, the stack formed would project only a negligible extent beyond the face of a 4½ in. partition wall into which it was built, and two flueways could be accommodated in a robust block convenient to handle.

The blocks were made of acid-resisting dense concrete, and the end edges of each were rabbetted to facilitate correct alignment and sound jointing in construction. The form and essential dimensions of the standard block and the special blocks necessary for constructing a multi-flue stock for gas fires are shown in Fig. 1. A flanged 5 in. dia. flue elbow with 110° bend used for connecting an instantaneous water heater is also shown. A two-storey block of this type was erected in the laboratory to obtain basic data relating to the performance of a flue channel in the system. To illustrate the compactness of a flue stack built with these blocks, sections through stacks containing 10 flues constructed (*a*) with these, (*b*) with pipes of circular section, and (*c*) with blocks containing channels with rectangular sections of dimensions according to B.S. 1289, are shown in Fig. 2.

Measurements of flow rate and temperatures in the flue were made with a convector gas fire and with an instantaneous multi-point water heater. The latter appliance was connected into the vertical section below the offset, and the base of the flue was sealed. The measured flow rate with the fire was 2,250 cu.ft. per hr., and with the multi-point 2,600 cu.ft. per hr. (at 60°F.). The maximumum temperature of the outside surface of the stack at equilibrium conditions with a radiant fire rated at 15,000 B.Th.U. per hr. was 125°F., and with an instantaneous water heater rated at 100,000 B.Th.U. per hr. 132°F., with an air temperature of 70°F.

The work showed that the flow resistances in a flue system may be determined, when the flue is functioning, by the measurement of total-head or static pressures and the flue gas temperature at suitable levels in the system.

The measured flow rate with the fire was of the order generally acceptable for the ventilation of a room of 1,000 cu.ft. capacity. The flow rate with the instantaneous multi-point water heater was 2,600 cu.ft. per hr. (at 60°F.), and this exceeds the minimum volume required to pass through the

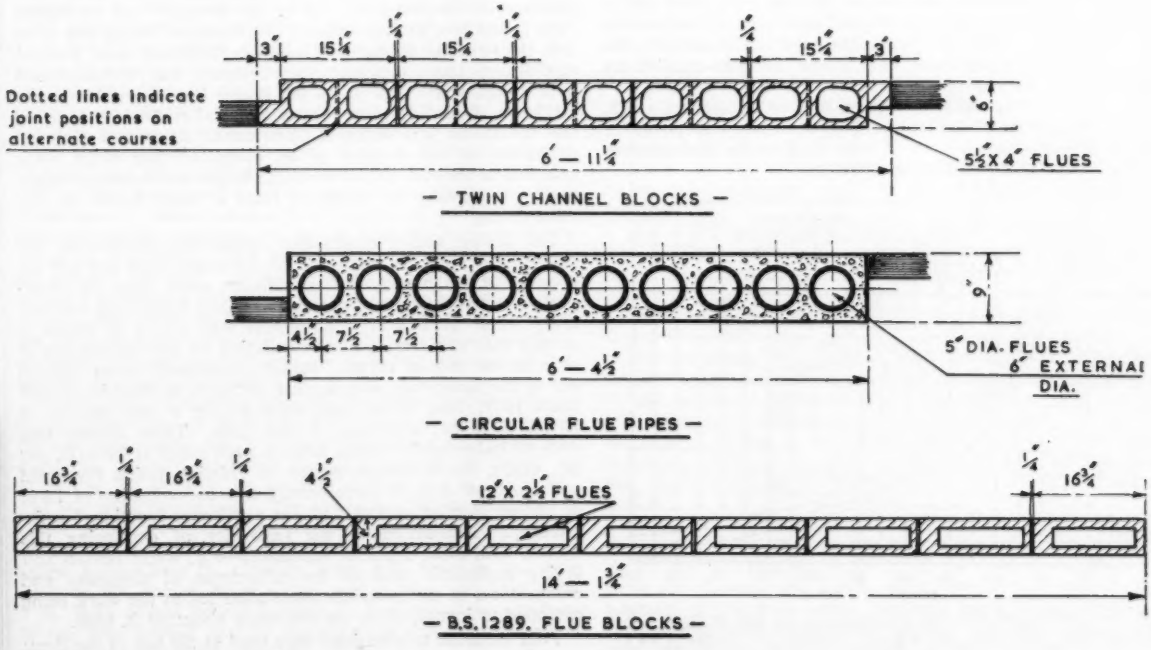
Dotted lines indicate joint positions on alternate courses
5½" x 4" FLUES
— TWIN CHANNEL BLOCKS —
5" DIA. FLUES
6" EXTERNAL DIA.
— CIRCULAR FLUE PIPES —
12" x 2½" FLUES
— B.S.1289. FLUE BLOCKS —

Fig. 2.—Section through stacks containing ten flues.

draught diverter to ensure complete evacuation of the products of combustion plus the diluent air drawn in through the draught diverter. In a subsidiary test on the water heater fitted only with a draught diverter, the products of combustion were just completely evacuated with no restriction of the draught diverter spigot. The minimum volume of the diluted products of combustion was 1,900 cu.ft. per hr. (at 60°F.).

The predicted flow rates with the space heater and the multi-point are within 3% of the measured flow rates. The close agreement permitted extrapolation of the results to taller flues, and the calculated flow rate with various appliances and for flues in a 10-storey building are given in Table 1. The appropriate number of offsets have been included according to the flue height.

TABLE 1.—*Calculated Volume Flow Through Flue.*

Appliance	Sensible Heat Input to Flue	Flue Height Storeys ..	1	3	5	10
		Number of Offsets ..	0	1	1	4
Radiant fire (Rating 15,000 B.Th.U/hr.)	6,000 B.Th.U /hr.)	Flow rate, cu. ft./hr. (at 60°F.)	2,400	2,700	2,800	2,300
Instantaneous water heater (Rating 100,000 B.Th.U./hr.)	10,000 B.Th. U./hr.	Flow rate, cu. ft./hr. (at 60°F.)	3,200	3,300	3,200	2,600

During the passage of the flue gases through a tall flue, there would be an appreciable heat transfer through the flue walls, which expressed as a percentage of the gross thermal input would be 26, 33 and 39% for heights of 30, 50 and 100 ft.

Measurements of the reduction in the sensible heat of the flue gases showed that the effective thermal transmittance of the flue in which an offset is present is almost identical to that obtained in a straight flue. (This would suggest that, while the heat transfer from the flue gases would be greater in the region of the offset where the velocity is higher, this heat transfer is local to a small area, whereas, in the case of a straight length of flue, the whole of the internal surface is effective.) By assuming that the value of U_d (the thermal transmittence per foot run of pipe) remains constant with height (*i.e.*, an exponential decay of sensible heat), the curves in Fig. 3 have been calculated. In curve (a) it has been assumed that the external air temperature is 40°F. and the flue gases from a space heater rated at 15,000 B.Th.U. per hr. are losing heat to an ambient temperature of 50°F., *i.e.*, the flue is considered to be in an outer wall and the ambient temperature of the flue is the mean of the temperature of the dwellings, 60°F., and of the external air temperature. A value of U_d of 1.94 B.Th.U. per ft. run per hr. °F. has been used and is the theoretical value of the thermal transmittance when the flue structure is cold. Curve (b) has been calculated with the measured equilibrium value of U_d and assumes equilibrium conditions.

Curve (c) corresponds to a flue within the building in which the ambient temperature for the flue is assumed to be 60°F. and the flue structure is cold. Curve (d) gives the temperatures when the flue is in thermal equilibrium.

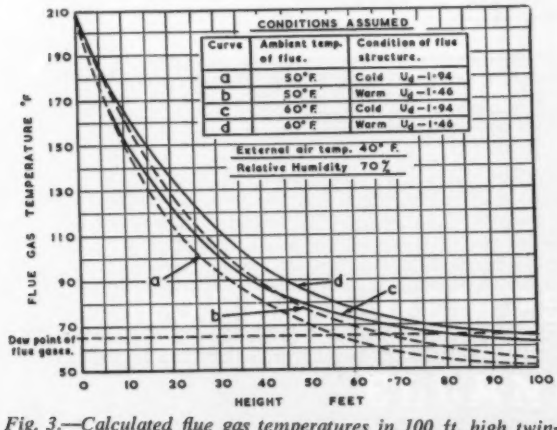

Fig. 3.—Calculated flue gas temperatures in 100 ft. high twin-channel flue with gas fire alight. (Rated at 15,000 B.Th.U. per hour.)

The humidity conditions have been obtained by assuming that the external air is at a temperature of 40°F. and the relative humidity 70%. The weight of water vapour introduced in the products of combustion was calculated from the gas analysis. The volume flow through the flue as given in Table 1 was used to determine the dew-point of the flue gases, and found to be 65°F. (The above volume flows were based on an external air temperature of 60°F. When the air temperature is lower, while the mass flow increases owing to the increased density of the ambient air, the volume flow referred to air temperature remains unchanged.)

The curves of Fig. 3 show that the flue gases are below their dew-point in the cases of (a) and (b) at heights above 55 and 65 ft. respectively. The quantity of condensation that may occur in the flue depends, among other factors, on the character of the flow, and this is intractable on theoretical grounds alone. Experience indicates, however, that condensation is insignificant in flues in which calculations show that similar conditions of humidity and temperature prevail.

Curves (c) and (d), which relate to an internal flue, show that, to within a few feet of the top of the flue, the gases are still above the dew-point. It is pointed out, however, that for the length of flue that extends through the roof the value of U_d is likely to be higher than the value adopted for the flue owing to forced convection which would result in a lower inner wall temperature, as well as greater heat loss. It would, therefore, seem advantageous to provide good insulation of the flue where this is exposed, and the insulation should preferably be of low thermal capacity to reduce the time to establish thermal equilibrium.

The curves have been calculated for a flue of height of 100 ft., but, as the flow does not alter appreciably with height when this is above about 50 ft., the curves may be applied to heights between 50 and 100 ft. At a height of 100 ft., the curves are asymptotic and could be extended without error.

In the foregoing considerations, no account has been taken of the influence of adjacent flues on the conditions in the flue when it is part of a multi-flue stack. In such a stack, heat will pass between two adjacent flues through the common wall so that a mutual warming effect will occur between them; this effect will be greater in a closely packed system than in an extended arrangement of flues.

Stacks as Entities

Considering the stacks as entities, it is evident that because the more compact stack has a smaller external surface it will suffer a smaller heat loss, and, consequently, the mean temperature of the flue gases and of the structure will be higher than in the less compact stack. Furthermore, being less massive, the structure of the more compact stack will reach thermal equilibrium more rapidly. The compact flue therefore not only occupies less floor space but is also less susceptible to the incidence of condensation. Some practical evidence supporting this conclusion was obtained when condensation was observed to persist in the corners of an elongated flue while none occurred in an oval flue of the same height and resistance when each was passing the products from a water heater of the same rating.

The notion that a single duct could serve to provide the channel for both the supply of air for combustion and for the disposal of the products of combustion arose from an observation that two balanced-flue space heaters functioned satisfactorily when fitted into a horizontal wall cavity in which it seemed that at times of poor ventilation an appreciable degree of vitiation would occur. Initial experiments were carried out in the laboratory with heaters of this type fitted in vertical ducts 10 ft. and 23 ft. high, each having a cross-section of 12 in. × 12 in., and open at both ends. These showed that with 10 balanced-flue space heaters, each rated at 20 cu.ft. per hr., alight, the maximum degree of vitiation which reveloped under natural draught corresponded to a concentration of 1.8% of carbon dioxide, and that all the appliances functioned satisfactorily. Realisation of the feasibility of employing this system with other types of appliances—*e.g.*, water heaters and drying cupboards—and of the advantages of simplicity and compactness of the complete installation led to the work being extended to investigations on two ducts about 50 ft. high.

Four different terminations were used at the top of the duct; a plain open end, a horizontal flat plate at 3 in. above the

plain end, a horizontal flat plate at 4½ in. above the plain end, and a 12 in. dia. extractor-type terminal.

Observations were carried out on the installation over a period extending from June to November, 1955, during which the wind speed ranged from 0 to 36 m.p.h. Measurements of conditions in the duct with various combinations of the appliances alight included the distribution of carbon dioxide and air temperature across the duct, the wall temperature, wet and dry bulb temperatures, and the flow rate of air. The influence of various terminations and of wind conditions were noted.

The results of this work were summarised as follows:

(i) The appliances functioned satisfactorily when used in various combinations up to the maximum of all heaters alight.

(ii) The observed air flow rate ranged from 6,500 cu.ft./hr. to 29,000 cu.ft./hr., the former occurring with no heaters alight and the latter with all heaters alight.

(iii) The maximum degree of vitiation of the air at the top of the duct corresponded to a concentration of 1.8% of carbon dioxide.

(iv) The stability of the burner flames in the appliances was satisfactory at all wind speeds.

(v) The maximum air temperature in the duct was 143°F., and the variation across the duct was of the order of 25°F. (Ambient air temperature = 72°F.)

(vi) The maximum dew-point observed in the duct was 91°F.

(vii) The resistance to air flow of the plain duct and terminal was 2.6 velocity heads and of each flue spigot projecting to the middle of the duct it was 0.6 velocity heads.

(viii) Only the flat plate at a distance of 3 in. above the top produced a measurable change in the air flow rate through the duct; this caused a lower rate. There was no measurable change in the flow rate on fitting the extractor-type terminal.

It was concluded from this work that the system was worthy of further development and that many problems concerning its practical application required more detailed investigation. Such problems concerned the method of construction of the duct in normal building materials, modifications to appliances, and determination of the flow resistance and thermal transmittance of a practical duct to provide data for the design of taller ducts. Accordingly, a second experimental duct was erected in a form as nearly as possible the same as that which would be proposed for incorporation in a block of flats.

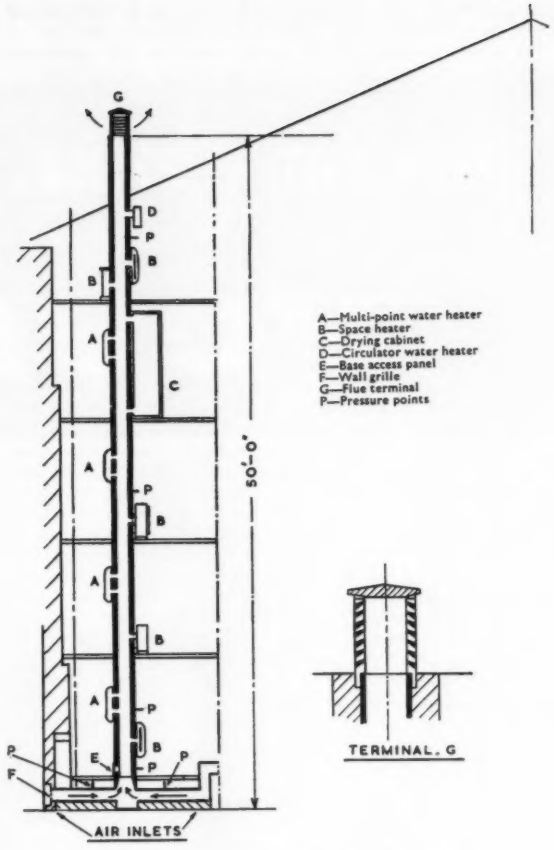

Fig. 4.—Second experimental 50 ft. duct.

Size of Duct

The results of the previous work and calculations indicated that, for a duct 100 ft. high and fitted with 12 water heaters and 12 space heaters, a cross-section of 144 sq. in. would be adequate. It was considered, however, from an architectural point of view, that the chimney breast formed around a duct 12 in. by 12 in. section would be too deep and that for the setting of some gas appliances it would be too narrow. It was decided, therefore, to use a duct of section 16 in. by 9 in.; this was subsequently modified to 15½ in. by 9 in. in order to facilitate cladding with standard-sized bricks.

For the entry of air at the base of the duct, openings from opposite sides of the containing building were considered necessary so that the pressure at the base of the vertical section would have a value between those developed on the opposite sides and would, therefore, be higher than the pressure which would be developed at the base if there were an opening on the leeward side only. In the building available for the installation, it was only possible to terminate the horizontal duct on one side of the building; thus the other end was open to the inside and not subjected to the full wind pressures which developed outside the building. A sectional diagram of this installation is given in Fig. 4.

The duct was formed of acid-resisting dense concrete blocks, all of dimensions as shown in Fig. 5, with the exception of the two base blocks, which connect the vertical and horizontal ducts; the standard block had overall dimensions of 17½ in. by 11 in. by 18 in. with an internal section 15½ in. by 9 in., and was used throughout. The lower base block contained a recess so that building rubble could accumulate at the bottom of the duct without restricting the air channel. A panel for access to the base for clearing debris was fitted in the duct close to the bottom floor. The vertical duct was clad with 3 in. thick breeze blocks bonded so that those on one face of the duct formed part of the partition walls of the rooms through which the duct passed.

Until measurements for determination of the flow resistance and heat transfer constants had been made, the duct terminated beneath the roof; it was later extended to a height of 4 ft. above the roof as shown in Fig. 4.

The fitting of appliances to the duct was considerably facilitated when it was found that holes could be cut without difficulty in the 1 in. wall of the concrete block. The following appliances were fitted to the duct:—

(i) Four balanced-flue instantaneous water heaters, without their air boxes and wind proof terminals,

(ii) six balanced-flue space heaters of five different designs, without their terminals,

(iii) a specially designed drying cabinet, and

(iv) a balanced-flue water heater circulator, without its terminal.

The drying cabinet was fitted with two hinged plates, one over the inlet and one over the outlet aperture. They were connected by a simple lever mechanism which caused them to close when the door of the cabinet was open and to be open when the door was closed, so that the duct always remained sealed from the room.

The appliances were fitted at positions similar to those they would occupy on the duct in a block of flats. The flue spigots of all appliances projected 1 in. into the duct, and the air inlets were flush with the inner surface of the duct. To ensure satisfactory sealing of the appliances to the duct, metal liners were cemented and screwed to the duct, and joints between the appliances and the linings were made with a sealing material.

In the building of the duct, no difficulty was met in handling or assembling the concrete blocks. Many holes, ranging from $\frac{3}{16}$ in. dia. for test points to 10 in. by 6 in. for appliances, were cut through the block walls, and in no instance did fracture of the wall occur, although some holes were cut through the joint between the blocks. The usual practice of first making a small hole through the wall to prevent fracture was carried out. The ability to cut holes easily is of great

practical advantage as it enables appliances to be fitted, either newly or as replacements, cheaply and wherever desired.

The air flow measurements gave values for the resistances which were of the order of those quoted as appropriate for smooth concrete ducts and for right-angled bends and tees, but the value of 0.5 velocity head determined for the inlet-air wire grille of free area 80% was appreciably lower than the resistance of about 1 velocity head usually quoted for a stamped grille.

The value of U_d for the cold duct obtained from the observations, was higher than that for steady thermal conditions, and it is suggested that the higher value should be used in calculations relating to the conditions in a massive duct when appliances are operated for short periods.

It seems possible that the air flow for a given system may be increased by incorporating a deflector plate in the horizontal duct below the tee. The merits and practicability of such a modification are to be examined.

Adding a terminal of the design shown in Fig. 4 to the end of the duct had no measurable effect on the flow through the duct. This indication is not taken as eliminating the possibility of increasing the air flow rate through the duct in wind conditions by such means since the performance of the terminal was not investigated to ascertain whether its design was optimum for producing a deficit of pressure. However, the results obtained with various terminations on both experimental ducts show that, provided the resistance to outward flow is low (*i.e.*, less than 0.5 velocity head) and the outlet is shielded from direct down-blow, a special design of termination is not necessary for the efficient functioning of the system.

The flow rate, temperature and vitiation of the air in the duct resulting from the operation of an appliance depends on the level at which it is fitted. A given thermal input into the duct at high level produces a smaller 'stack' effect and, consequently, a lower air flow than when introduced at a lower level. Assuming that the same volume of carbon dioxide is associated with the thermal input in both cases, the vitiation will be greater when the input is at high level. This point is of importance in designing a duct on the basis of a limiting degree of vitiation, since the possibility of only the upper appliances being alight simultaneously must be taken into account.

Climatic changes occasionally give rise to down-flow of air in unheated conventional flues. This prevents the products of combustion from an appliance entering the flue where their thermal content would reduce the down-thrust of the air in it. In the single-duct system, the products of combustion discharged from an appliance must enter the duct and, in doing so, quickly raise the effective temperature of the duct air so that the flow in the duct is reversed.

Calculations have been made of the significance of inversion by assuming conditions favourable to the promotion of a high degree of inversion and calculating the time taken to effect reversal by the discharge of products of combustion into the duct. Such conditions may be taken to obtain in a duct 150 ft. high with an outside air temperature 10°F. above that of the duct walls. The time taken for the establishment of reversal by the introduction of 13,000 B.Th.U./hr. sensible heat is approximately 9 sec., during only a small interval of which a degree of vitiation exceeding the normal maximum will prevail. The effect on the combustion of an appliance under such transient conditions was observed to be negligible and, hence, the effect of inversion conditions on the performance of the duct may be ignored.

The flames of the appliances, particularly those of the space heaters, were more stable than in their counterpart balanced-flue appliances when fitted to a wall and exposed to high-velocity winds, despite the omission of the windproof terminals. This comparative performance is explicable in that the terminations of the appliances in the duct were subject only to steady air flow which did not exceed 7 m.p.h. and was always in a direction vertically past the terminations.

The initial instability of the flames of the water heaters due to incomplete sealing of the combustion chambers indicated the importance of ensuring satisfactory sealing in the design of appliances for use on the duct.

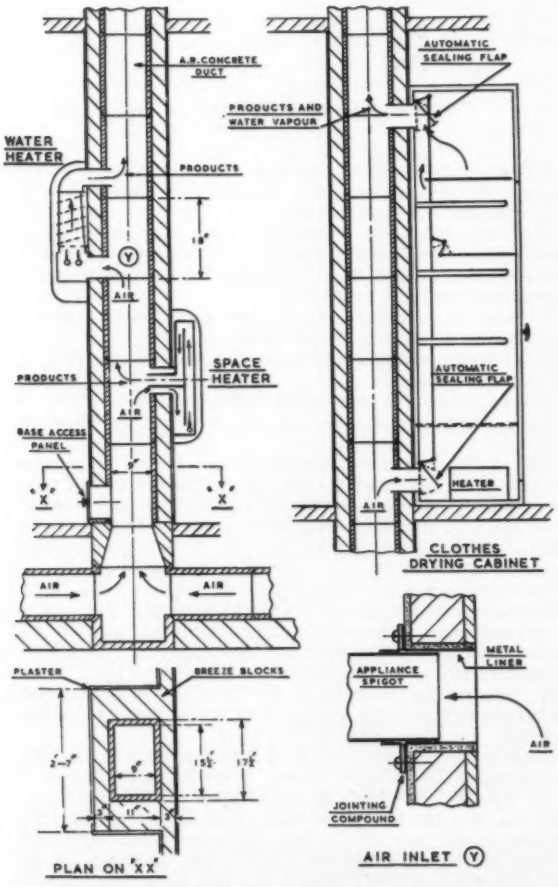

Fig. 5.—Method of connecting appliances to duct.

Satisfactory Combustion

Combustion of all appliances was satisfactory with a vitiation corresponding to the maximum value of the mean carbon dioxide concentration of 1.8% which occurred in the duct during normal operation. The carbon monoxide to carbon dioxide ratio of the products from the circulator water heater more closely approached the limiting value of 0.02 than the ratio of the other appliances. Should further experience indicate that a better combustion performance is desirable, there is little doubt that this can be effected.

From the results of the thermal efficiency tests on the representative appliances fitted to the duct, the efficiencies of the adapted appliances can be taken to be the same as their counterparts when used conventionally. It was expected that the efficiency of the drying cabinet would be greater when other appliances were in use below it, due to the inlet air temperature being higher; it would appear, however, that the increased humidity of the air offsets the possible gain due to temperature.

As in the case of the individual flue, definitive prediction of condensation is not possible, but calculations, coupled with experience, suggest that significant condensation is unlikely, and a guide to the possibility of condensation occurring has been made assuming an external air temperature of 40°F. and a natural relative humidity of 70%. Taking the case of a 100 ft. duct designed for water heaters only, it can be shown that, with the three lowest heaters alight, the duct air will reach its dew-point at 80 ft. above the highest of the three heaters, and with the lowest heater only alight the dew-point will be reached at 100 ft. above it.

In the case of a 100 ft. duct designed for space heaters, when all the heaters are alight the dew-point will be reached at 10 ft. above the highest heater. The assumption is made in each of these cases that the cooling of the duct air occurs under cold duct conditions. If thermal equilibrium conditions are assumed in the case of the space heaters, the height at which the dew-point will be reached will be much higher than 10 ft. above the top heater.

Whether, and to what extent, condensation will be deposited

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on the walls which will be below the dew-point of the air depends on a number of factors, including the state of flow of the air near the wall of the duct, which are only assessable qualitatitively. However, calculations suggest that the extent of condensation is unlikely to exceed fhat arising in conventional individual flues of the same height where experience has shown that, quantitatively, condensation is unimportant, so that in the single duct significant condensation may be discounted.

The condensation found inside unlit water heaters near the top of the duct was thought to result from circulation of air from the duct through the heaters, caused either by thermal inducement due to the heater bodies being cold, or to a pressure difference in the duct air at the heater apertures. It should be mentioned that, at the times when dew occurred in the unlit heaters, the air temperature around the duct was 52°F. and both the heaters and the duct were subjected to forced cooling by a 2 m.p.h. wind in the building, and, furthermore, the water heaters below had been in operation for some hours. As appliances installed in occupied flats would neither suffer as much heat loss nor be subjected to the effects of such prolonged operation of the lower heaters, the formation of condensation in any significant quantity is unlikely.

The duct with appliances fitted to it consists, from an aerodynamical point of view, of a complex system in which there is a main flow through the duct and subsidiary flows through the appliances, which form alternative paths in parallel with the duct. For the satisfactory operation of the appliances, not only must the air passing into the burner have a carbon dioxide concentration below a limiting figure, but the appliance must induce an adequate air flow out of the main stream and discharge this back into the main stream. The volume induced by an appliance will depend both on the velocity of the main stream and on the volume flow through the duct. A design criterion of 2% of carbon dioxide would automatically ensure that there would be an adequate volume flow through appliances other than drying cupboards, for which the design must be based on a minimum volume flow through the duct of 2.5 times that required for each dryer.

Hazard Does Not Arise

Since all the appliances are constructed and installed so that the products of combustion are excluded from the dwellings in all circumstances, the usual consideration of the hazard due to carbon monoxide entering the dwellings does not arise, and only the effect of vitiation on service obtained from the appliances need be considered.

The tests on the appliances show that there is no significant deterioration in combustion up to 3½% carbon dioxide vitiation and that the change in the thermal efficiency up to 1% carbon dioxide is small.

It would seem reasonable to design the system on the basis that vitiation of 2% of carbon dioxide occurs when the probable maximum number of appliances are in use and air flow through the system results solely from the heat contained in the duct. Normally, vitiation will be considerably lower as fewer appliances will be in operation, and wind conditions will cause greater flow rates. Furthermore, only the highest appliance will be subjected to the designed degree of vitiation.

The probable maximum number of appliances used in calculations depends on the type of appliance fitted to the duct. In the case of space heaters, it is assumed that all will be in use together, and in the case of instantaneous water heaters not more than a third of the total number will be used simultaneously.

Accepting the value of 2% of carbon dioxide as the criterion of design, and assuming a particular configuration of the system between the inlets and the base of the vertical duct, the requisite cross-sectional area of a duct of given length and fitted with appliances of given ratings may be calculated from expressions developed theoretically.

Although down-flow in the duct cannot cause emission of products into the dwellings served by the system, it is desirable for the top of the duct to terminate in a region not subject to high static wind pressures which would oppose the thermally induced flow and so cause vitiation in the duct to exceed the design value.

The use of a fan to motivate the air flow in the duct has been contemplated; although this would provide positive ventilation of the duct, the investigations indicate that such a device is not necessary. The main advantages would be in the elimination of one limb of the horizontal duct and would allow freedom in locating the termination of the duct, but it would seem that, owing to the need to limit the velocity of the flow in the duct, it would not be possible to make a significant reduction below the area required for a system operating on thermal draught.

The practical value of the system is perhaps best assessed by drawing comparison with installations of conventional and balanced-flue appliances, since a similar heat service is obtained with either of these systems.

Most of the advantages gained with the single-duct system follow from the ability to site the appliances on inner walls of the dwellings. The elimination of wallface terminals meets the objections often raised against them on the grounds that they mar the elevations of the buildings, and avoids the difficulty frequently met in selecting for such terminals positions which are free from troublesome wind effects.

The ability to locate appliances on inner walls permits freer planning of the gas equipment, since the restriction on the siting of appliances in positions remote from outer walls, imposed by the need to use long runs of flue pipe, does not arise. With the system, it is possible to install space heaters, water heaters and drying cabinets in such places as halls and inner rooms. The sheltering of the air and flue apertures afforded by their location in the duct results in the elimination of the windproof terminals, with consequent cheapening of the appliances, and in the case of water heaters at the same time avoids exposure to freezing conditions at times of extreme winter weather. The absence of flue equipment, draught diverters, flue pipes and terminals leads to neater and cheaper installations, and easier substitution of appliances where a change is desired. Some gain in the general heating of the building is achieved from the products of combustion as they pass through the duct; in the case of the space heaters, approximately 85% of their gross thermal input is absorbed by the building.

It is inherent in the design of the system that appliances used must have combustion chambers sealed from the room. Of the appliances normally flued, only fires are precluded due to this limitation, while it would seem that the range of appliances suitable for the system includes forced-convection space heaters—adequate for partial or complete heating of a dwelling—in addition to the instantaneous and circulator types of water heater, the convector space heater and the clothes drying cupboard used in the tests.

Saving Effected

In comparison with the conventional methods of installing appliances with wallface terminals, the cost of the duct and the room space occupied by it are additional, but saving is effected on flue equipment. Compared with individual flue installations for appliances providing the equivalent heating services, the single-duct system shows appreciable saving in building cost and space.

Both systems described are basically simple in that the flow ducts are simple channels to which a theoretical treatment of thermally induced flow is rigorously applicable. It would appear, from the good agreement between the observed and calculated performance, that the design requirements of either system can be reliably specified using the formulæ developed theoretically and the measured physical constants of the system.

The multi-flue system described is satisfactory for tall internal flues with gas fires and instantaneous water heaters. The work indicates that smaller flue channels would be adequate for gas fires where a ventilation rate lower than that normally attained with a gas fire flue is acceptable. The channel section is more than adequate for the disposal of the products of combustion from a large instantaneous water heater plus the minimum volume of diluent air required to be drawn through the draught diverter in order to prevent spillage.

A stack formed with the blocks has maximum compactness consistent with a projection in the room that is acceptable architecturally. The compactness, besides effecting economy in space, also tends to reduce the incidence of condensation.

A single duct suffices to provide the air for combustion and to dispose of the products of combustion from a number of appliances of various types fitted to it; the system so formed

is sealed from the dwellings. The system functions independently of the ventilation of any part of the building in which it is installed and operates with a high thermal efficiency. The cross-sectional area of the duct will range from about 0.2 sq. ft. to 1.7 sq. ft. for ducts 50 ft. to 150 ft., according to the height of the duct and the number and the type of appliance fitted.

An appliance for use in the system should satisfy the requirement of B.S.717 when tested with air vitiated to 2% of carbon dioxide. Although not normally required to meet this standard, modern appliances have a good combustion performance at overload rate with clean air, which indicates that they will satisfy this requirement.

The investigations described have provided data on the major problems associated with the two systems. The installations afford the means for further work on aspects requiring more detailed knowledge, while, as with all flue systems, much will be gained from experience in the field with installations operating in occupied blocks of flats.

DISCUSSION

In the joint discussion which followed the foregoing papers

Dr. R. S. Edwards (Chairman, North Eastern Gas Board) said that from figures he had obtained from official sources it appeared that in 1955 over 26% of all dwellings erected, other than by private enterprise, were in the form of flats. He could not obtain the proportion in multi-storey flats, but it was evident that the majority of the flat dwellings were in the form of multi-storey flats.

This posed a definite architectural problem. The headquarters of his Board were cheek-by-jowl with what he thought was still the largest single block of flats in the country, if not in Europe, the Quarryhill flats at Leeds. If they were being built today and not in the early 30's, the forest of chimney pots would not be a feature of the skyline.

If they were to maintain the many undoubted advantages of the use of gas for heating purposes in multi-storey flats, the problem of flueing must be solved and it was becoming a major requirement of the industry to provide the architectural profession with the solutions.

Mr. Oliver Cox (Development Architect, London County Council) remarked that the London County Council was following with great interest the developments in shared and branched flues.

From the architectural point of view, their interest in branched flues was related to the savings which could be brought about in relation to floor space and additional simplicity in planning and in structure resulting from the introduction of the dramatically reduced areas occupied by these flues compared with conventional individual flue systems.

In regard to cost, they estimated that savings of up to £20 per dwelling might accrue from the introduction of such systems. In addition to that, they anticipated savings in floor area of up to an average of 5 sq. ft. per dwelling.

In areas of high density housing, the question of the frontage of flats and the actual blocks was of extreme importance in order to achieve the layouts of an open character at which they were all aiming. The question of reduced frontage was considerably assisted by their cross-wall system of construction which was becoming standard practice in the London County Council and elsewhere, which, by deepening the dwelling, allowed for reduced frontages.

Individual flues were combined in the position of the structural cross-wall in order to save further valuable space being taken up by them. This was making them not only complicated structurally but bulkier, and the bulkier cross-wall again increased the frontage.

The architects, therefore, welcomed the study into the branched or shared flue systems, because they could take the flue away from the cross-wall, allowing it to return to its purely structural function, occupying less area on the plan and reducing the frontage.

The Council's experience in the use of branched flues had so far been restricted to experience with solid fuel burning appliances, but it might be of interest to report briefly on the result of the experience to date.

So far two installations had been completed in London, using the shunt flue blocks and terminals which were imported from Holland for the purpose of the experiment. The first installation was strictly in accordance with the lines of the Continental practice, giving only 7 ft. branches into the communal flue. This installation was tested thoroughly by the Building Research Station, and the results of those tests appeared satisfactory for closeable stoves and for free-standing open fires but were unsatisfactory with the conventional type of open fire. The type of stove actually installed was the free-standing open fire, and that had been in use for the best part of a year with apparently totally successful results. The first installation was in a five-storey block of flats.

The second was installed in an 11 storey block of maisonettes. Because the maisonettes were two storeys in height, it was possible to have an approximately 15 ft. long branch into the main flue. Again, tests were conducted by the Building Research Station with satisfactory results. The type of stove installed there was the closeable stove. These maisonettes had been occupied since August of this year, and so far the results appeared to be totally satisfactory.

The results of these experiments had been that the Council had decided, as a first stage in extending the experiments, to go ahead immediately with a further eight experimental installations in blocks from 11 storeys to six storeys in height and also to attempt to devise a form of branched flue suitable for use with the conventional open fire. In regard to gas fired appliances, the Council had no direct experience. It had so far conducted no experiments into the use of gas fired appliances with shared or branched flues, but it had been following very closely and with considerable interest the work which represented the research embodied in the two papers. So far the application of the results appeared particularly relevant to the ventilating of gas fired drying cabinets, and tests were shortly to commence on the installation of gas drying cabinets with branched flue ventilation.

In Low Blocks

In low blocks the heating and hot water system provided by the open fire and back boiler still proved extremely popular to tenants and was economical. Therefore, in their low dwellings generally they were adopting solid fuel burning appliances.

However, their experience in the higher floors of their 11-storey blocks—those were the highest that they had so far built in London—led them to believe that in many cases these high blocks demanded some more general form of central heating. They were proposing to build considerably higher than 11 storeys, and they considered that in those cases some form of central heating was essential.

There were, however, many marginal cases between those two extremes, and it was in those marginal cases that they proposed to investigate the application of the gas heating and hot water system as investigated experimentally by the authors.

Mr. J. B. Dick (Principal Scientific Officer, Building Research Station): said he would like to take up the question of shunt flues and branched flues, which still required considerable experiment in the field and also in the laboratory.

Mr. Cox had told them of their co-operative work in examining the performance of solid fuel fires with shunt and branched flues. He had mentioned that the ordinary open fire was not successful in one installation but that the new free-standing open fires or closeable stoves were. That raised a fundamental problem about the appliance itself. The authors in their papers had dealt with the flues viewed separately from the appliances. He thought the next stage was to fit on the appliance and put in the resistance of the appliance so that one could predict what air flows one was likely to get.

The reason why the simple open fire was not successful in the installation was that it required about twice as much air in order to carry away the products of combustion as did the openable stove or the stand-in fire. For instance, a typical figure for open fires was that one needed 5,000 cu.ft. of air an hour to carry away the products of combustion. With the stand-in type one might get to a figure of 2,000-3,000 cu.ft. per hour.

By changing the appliance they did not really change the volume of air that was passing up the flue in that particular case, but what they did was to cut down the smoking point of the appliance. In relation to the area required to remove the products of combustion, he thought the direction in which they must go was to reduce the smoking point and also learn

a little more about the interaction between the appliance and the flue system itself, because this would become more important as the design became more streamlined.

He was very interested to see the theoretical prediction of flow in the U-duct and 'Se-duct.' He did not know whether these should be differentiated quite as much as had been done. Technically, they were very similar, but there were two points of difference. The first was that the U-duct had an extra resistance corresponding to the downward limb of the U in introducing air to the bottom of the duct. However, Mr. Carne had shown how allowances could be made for this, and it appeared that Mr. Carne's data were confirmed by Mr. Bennett and Mr. Purkiss, and this would enable prediction to be made. The residual points where they differed were in relation to the question of inversion. The other authors would not agree in relation to the U-duct, but, on the other hand, Mr. Carne had shown that it would not prove very troublesome in practice.

Mr. Felix Walter, F.R.I.B.A., remarked that the authors of the paper on shared flues had described the precast concrete blocks used in the construction of the first two sets of branch flues erected in D Block at the Abbey Orchard Street Estate. Although these blocks were of a very high standard of finish, it was found that when bonded into the existing fabric they were insufficiently flexible, or perhaps he should say, flexible at an uneconomic price. The slightest change of wall face, or the need to alter vertical direction, called for special blocks made from specially constructed moulds. Furthermore, the remarkably thin walls of these blocks did not meet with the approval of the authorities who demanded a minimum of 2-in. breeze casing on all faces except where bonded into existing masonry. Had the blocks been cast with thicker walls the problem of site handling would have been quite considerable.

Other difficulties on site suggested that this medium, in conversion work, had certain disadvantages. The vertical tolerance of each precast unit was insufficient to take up floor-to-floor height variations without special make-up units. To distribute the dead load of the flues, units at each floor incorporated projecting concrete collars resting on joist trimmings to support one storey weight, but this did not satisfy the District Surveyor who called for a reinforced concrete slab at the foot of the shared and branch flues to carry the whole load. In addition, an amount of labour in cutting away and bonding the flues into adjoining brickwork added considerably to the cost, and finally where delivery of units was of the uttermost importance, the time taken in forming moulds, casting and curing, as well as the risk of fracture in transit suggested that some alternative material, possibly a dry assembly unit for speed in erection, should be tried in the future.

A few months after the completion of these precast concrete branch flues in May of this year, he invited the Gas Council, with the consent of his clients, to erect a further branch flue but this time in heavy-duty circular asbestos pipe. The previous experimental installation had proved two points: (a) that the principle functioned remarkably well and (b) that the cost of the flue under normal conditions in conversion work was prohibitive. The intention, therefore, of this second stack was to discover an alternative which might compete with the cost of traditional arrangements for venting instantaneous bath water heaters.

This project was carried out in the adjoining Block F on the same estate. From the Gas Council's point of view, the underlying principles were similar to the D Block installation, the branches from heaters running vertically for approximately one storey height before joining the common flue. The branches were of 4-in. internal diameter and the main or common flue 8-in. with 135° reducing tees at each junction.

To eliminate all forms of casing, a large vertical duct was provided. This was 2 ft. 3 in. wide and the full width of one room—8 ft. 6 in. in most cases—and was repeated directly above throughout the complete height of the building. It was designed to accommodate a 15-in. diameter refuse chute, twin 4-in. single stack preformed soil units and branch wastes, all services, the branch flues and also sample traditional water heater vents. The entire duct was permanently accessible throughout its complete height.

From everyone's standpoint, and particularly from the contractors', this dry construction branch flue had proved to be very satisfactory. The 8-in. diameter heavy duty pipe delivered in storey heights is remarkably light to handle and simple enough to adjust to site peculiarities, while the speed of erection had had its effect on the total capital cost. Little trimming of floors was necessary by reason of the margin of flexibility permitted about the reducing tees and the whole stack was plumbed beforehand to take advantage of the free spaces between existing joist positions.

This simple installation and its speed of erection had had beneficial effects on the capital cost, and although this second experiment was still more expensive than the traditional method erected in the same duct, it did offer other advantages denied to the older techniques. In the first place, the flexibility of planning was considerably increased, while expensive cutting through solid outside walls, the provision of scaffolding and unsightly terminals were eliminated.

Where two or even three sets of bathrooms per floor could be grouped together, and repeated on all floors, so also could the branch and communal flues. This internal grouping of plumbing on inside walls was in complete opposition to the old geyser or even to the new streamlined appliance which were still fixed on the outside wall of a room just to simplify the venting of the heaters, but it was nevertheless thoroughly bad practice and he was glad to find that the latest British Standard on Frost Precautions went out of its way to condemn the installation of all water services on outside walls.

One final point in favour of the branch flue—and again he referred to the converted building rather than the new project. In many buildings there was a great depth from front to rear and frequently the centre of this depth was poorly lighted. Surely, here was a case for internal bathrooms with gas water heaters vented into branch flues—and here again this use of such badly illuminated areas for bathrooms and the like released other floor space for additional habitable rooms. Thus the rental from this additional income-producing area would far exceed the difference in capital cost between the antiquated terminal and the contemporary shared flue.

Mr. N. Barnes (Chief Development Engineer, Ascot Gas Water Heaters Ltd.) said that since the war instantaneous water heaters, together with convector space heaters, had been the subject of development work which resulted in their introduction as 'balanced flue' appliances. The feature denoted by this name was the design of the externally situated inlet and outlet ducts in such a manner that the ambient pressure was balanced in all wind conditions, satisfactory combustion being maintained accordingly. This feature, however, was really the means and not the end. From the point of view of the installer and user, these appliances offered a neater installation than the normal appliance with flue, and in many cases they could cope with unsatisfactory fluing conditions better than a normal flue, but their most important feature was the provision of a combustion chamber which was sealed from the room. During the past few years these appliances had played their part in providing individual installations offering the advantages quoted.

A new situation had now arisen. By utilising the U-duct or 'Se-duct' schemes described, appliances having this feature of a room-sealed combustion chamber could now be provided in a form which offered an extremely economic and attractive installation in cases where a suitable duct could be incorporated in the design of a tall building. In order to define the significance of this, it was perhaps opportune to select a generic term for appliances having a room-sealed combustion chamber—sacrificing accuracy for brevity to use some such term as 'room sealed appliance' or 'sealed circuit appliance.' He noted that in his introduction Mr. Carne used the term 'aerodynamically isolated appliance.' He felt that this was very attractive from the scientific point of view but perhaps rather a mouthful for the term he was suggesting. The position then was that room-sealed appliances were available either in the form of individual balanced flue appliances or as a group of appliances fitted to a suitable duct in a multi-storey building.

He had one or two comments as a result of work done on balanced flue water heaters. Many flue and terminal designs were tried for these, but no way of ensuring proper combustion in all wind conditions was discovered other than by arranging the inlet and outlet in close proximity. Experiments were conducted with the inlet and outlet vented to atmosphere at their natural level—*i.e.*, at the bottom and top of the appliance—but whatever terminals were used with this basic arrangement, interference with combustion in certain wind conditions was

excessive. This was mainly due to pressure variations caused by velocity pressures or eddies across the wall surface. When, however, the simple inlet and outlet arrangement was utilised with the ducts described in the paper, consistent combustion was quite simply obtained. The duct provided a column of air across the appliance inlet and outlet which was free from such velocity pressure variations. Any pressure difference between the inlet and outlet of the main duct would vary its air flow, but with the dimensions established this had a negligible effect on the parallel appliance circuits.

The direct inlet and outlet arrangement was not merely simpler mechanically; it also made the thermodynamic design of the appliance less onerous, since it avoided the thermodynamic loss which was inherent with a coincident inlet and outlet.

Mr. B. Wulston Atkins (Special Service Manager, South-Eastern Gas Board) said that the outstanding practical developments in new flueing systems for gas appliances made in this country over the last few months were by no means obvious from the two papers. When in August, 1955, a small party visited Belgium and Germany no 'unorthodox' flue blocks were being produced commercially in this country although some hundreds of the Belgian design 'Shunt' concrete block branch flue installations had already been made in Belgium, Holland, and France; and Junkers, and other German firms, were already installing gas water heaters in common flues of asbestos cement construction in tall blocks of flats up to 14 storeys.

A great deal of technical research had certainly been carried out, at Watson House for some three years, and at the Old Kent Road experimental laboratory installations of both the 'X' twin channel concrete block flue and the original 12-in. square galvanised version of the 'Se-Duct' had been erected; but at this time the most that could be said commercially was that the new experimental flue systems appeared to have great promise.

Today, only 15 months later, one English maker of flue blocks could himself offer from stock 'X' blocks, 'Se-Duct' blocks and English made 'Shunt' branch flue blocks, and doubtless other flue blocks incorporating the result of the recent research would quickly be available when required. Two installations of branch flues for water heating had already been made in Abbey Orchard Street and had been fully reported.

Very largely as a result of the work sponsored by the Gas Council, this country was, therefore, now in the vanguard of modern flue designs.

From discussions with interested authorities, some of the advantages offered by the 'Se-Duct' system could be summarised under two main headings.

From the architect's point of view the installation of 'Se-Ducts' (1) offered him increased flexibility of layout; (2) provided him with a means of installing the highest efficiency gas appliances in any part of the dwelling instead of, as at present, only in rooms with outside walls; (3) enabled him to design elevations without wall terminals; and (4) offered him substantial savings in building costs, and increased 'free' space when compared with existing traditional solid fuel installations.

From the local authority or developer's management point of view:

(1) Individual high efficiency gas appliances could be installed to provide space and water heating at running costs to their tenants on two-part tariffs comparable with those of traditional solid fuel methods. (2) Where it was the developer's intention to install central services the 'Se-Duct' offered him an ideal method of installing instead indirect gas air heating units in each dwelling at a lower capital cost per dwelling than that involved in the installation of central systems either by conventional hot water radiators or by central air ducts. In this way 'hidden' charges in the rents could be avoided, and freedom was left to each tenant to run his own installation to suit his own needs. Actual experience over two years had shown that, when gas air heaters are used 'selectively'—*i.e.*, to heat different parts of the dwelling as and when required—adequate comfort conditions could be obtained for under 500 therms a year for a normal three-bedroom type of house. The heat available in this way undoubtedly offered a higher standard of comfort than that normally available in traditional types of dwelling—and at running costs comparable to solid fuel.

(3) Even if heating was to be provided from a central installation the 'Se-Duct' would provide an ideal method of installing 'sealed' gas water heaters in the most convenient positions on internal walls thus eliminating possible freezing difficulties and reducing maintenance and initial plumbing costs.

(4) Where it was the policy of developers to install individual drying cabinets, 'Se-Ducts' provided a ready and low cost method of flueing and the maximum flexibility in positioning them.

He had dwelt on the commercial advantages of the 'Se-Duct' owing to its unusual possibilities, but it was not the answer in every case. For open type gas fires, for example, either conventional type 'X' blocks or branch flues provided the cheapest and best method of installation.

Thanks to recent flueing developments and more efficient gas appliances, gas on two-part tariffs could now provide domestic heat services at running costs generally comparable with other fuels; and this fact, and the advantages of the Clean Air Bill, should enable the industry greatly to increase its domestic gas consumption.

Mr. H. A. Blum (Ewart and Son Ltd.) said it was most encouraging for a manufacturer to see the great number of flue and flue/ventilation systems to which they now find that gas appliances could be connected; for, let there be no mistake, the possibility of finding a technically and visually acceptable solution of the flue problem would give a strong impetus to the future installation of gas appliances.

He hoped he was right in concluding that shared flues of different types were quite satisfactory, and that the regulations forbidding them were based more on prejudice than on fact. He was particularly glad to see that the simplest form, the ordinary common flue, was about as good as any, especially for instantaneous water heaters, in which he was particularly interested.

He was also glad to find a comparatively simple method for anticipating the possibility of condensation, and from some examples it would appear that the risk was negligible for instantaneous water heaters. He would like, however, to give a word of caution in the case of storage heaters and particularly in the case of gas fires which were likely to work for long periods at a greatly reduced gas rate. Would the dilution of the flue-gases of a convector at lowest setting be enough to prevent risk of condensation? He remembered some cases where they had given local trouble, and, in the case of chimneys previously used with solid fuel fires, caused considerable expense. It had been found that the shape of the flue-connections was of some importance, and that oblique inlets seemed to reduce the risk compared with square inlets.

As regards multi-fire systems, he called attention to a system which had been successfully used in Switzerland for many years, under the strict supervision of the building and fire authorities. In this system, each flue, which was open at the bottom, served one flat and was blocked completely at about 2 ft. above the floor level of the particular flat. A ventilation grille opening into the bathroom or kitchen in which the appliance was fitted was broken out below the block course, and the appliance was flued in the customary manner into the top section. Consequently, the same flue supplied fresh air and removed the flue gases, so that bathrooms fitted in this manner could be on the inner ends of corridors, halls, etc., and needed no additional fresh air inlet. They were then as far removed as was technically possible from the danger of freezing.

Mr. D. R. Wills (Watson House) said that from some points of view the provision of hot water and heating by central services was attractive, but there was increasing evidence that it was sometimes difficult to justify them on economic grounds. There was also evidence that there were many advantages in providing tenants with independent heat services, under their own control, so that they paid for what they got. There was little doubt that the gas industry could make a reasonable contribution to the solution of the problem of providing independent heat services in flats, either by gas or by coke and gas, but only if it was possible to install a flue system of some form or another.

As mentioned by the authors, there had been a lack of fundamental design data, particularly in respect of the very tall flues, and it had been necessary over the past few years to extrapolate sometimes beyond what would be considered a normal range. This had given the technician a good deal of anxiety, but in spite of lack of accurate information some assessments of the problem had been made and several blocks of 10 to 12 storey flats

had been equipped with individual flue systems to which gas fires had been fitted. Some had been in use for several years and had been kept under close observation. The flue systems included circular asbestos cement and the rather more massive construction where acid resisting cement liners had been used. These flues were over 100 ft. in length and were nearly all grouped internal flues. As far as could be measured and assessed from visual observations at the terminals, condensation had not occurred. In this connection he was interested in the prediction formulae given in the papers, because these suggested that condensation should not have occurred anyway! This was certainly a great relief to him. The important thing, however, was that with the present data it should be possible to check back on some of the existing installations, recently built, and perhaps confirm the general validity of application of the present data to other situations.

In flatted dwellings ventilation was almost as important as heating, and the flue remained one of the better and more positive forms of ventilation as long as some attention was given to correct sizing. The blocks described, when ventilating a gas fire, provided just about enough ventilation and it was more or less controlled. There was very little difference in flow, whether the flue extended for one or 10 storeys.

Another important point was the building heat gain from the flue heat. Though it might be a little difficult to assess the direct usefulness of this heat, it should not be ignored in assessing the overall efficiency of a system.

Referring to the single duct with sealed appliances, the importance of this was obvious, particularly in relation to independent water heating appliances, because there were signs that even where central heating was considered there was an advantage in separating the hot water services, by provision of independent means under the tenants' control and paid for by them.

In a written contribution to the discussion, **Mr. A. R. Bennett,** Research Manager, Radiation Ltd., states that because flues lack the glamour of delta-wing aircraft and have little military value, the application of aerodynamic principles to their operation has progressed less rapidly than in other fields. Likewise, from the standpoint of the practical engineer, the picture of a column of gases outside a flue tilting the scales against a corresponding but less dense column inside, and hence causing the latter to rise, gives an illusion of simplicity to the process. The two papers under discussion go far to shatter any such illusion and at the same time, to emphasise the importance of the products disposal arrangements in the economics and hence the competitive potential of gas as a fuel.

In the paper given two years previously to the Institution, by Dr. Reichert and himself, he had laid stress on the handicap suffered by gas appliances as a result of their association with orthodox flues with their dependence on ambient conditions and generally high cost per appliance. The progress evidenced by the present authors, both in reducing the cost of products disposal in certain circumstances and in increasing flexibility of installation was greatly to be welcomed, and it was to be hoped that equally rapid progress would be made in indoctrinating architects and building authorities in the full use of the principles described.

It was particularly fortunate that the conditions for satisfactory operation of the Se-duct could be so readily met, and that several types of appliance suitable for operation on this duct were already available. The authors' figures relating to thermal efficiency were interesting, and as with most internal flues, it appeared that such a duct could make a substantial contribution to the overall heating of a building, although obviously in a large block of flats some tenants would benefit much more than others from their neighbours' waste heat.

While the U-duct experiments described by Messrs. Bennett and Purkis had yielded less satisfactory results so far, this did not appear to be fundamental to the duct itself, and no doubt the repositioning of inlet and outlet within the duct would avoid excessive vitiation. His experiments with Dr. Reichert on B.F. terminals had shown clearly that there were many conditions in which products of combustion discharged near a wall tended to flow along the wall with slow dilution as compared with those discharged in a relatively free stream. A difference of level of inlet and outlet of at least 1 in. relative to the adjacent wall was found to be essential to avoid feedback of products under some wind conditions. One would expect that inside a small duct such effects would be even more marked owing to the greater stability of the flow. Thus, while Messrs. Carne and White rightly concluded that simpler and hence cheaper appliance terminals could be used in the duct, as compared with individual B.F. installations, this did not mean that products could be discharged and air taken in indiscriminately. It seemed, however, that sufficient design information was now available to avoid any pitfalls in this connection.

In another written contribution, **Professor Joh. Körting,** of Karlsruhe, says it is really impossible to do justice to the paper by Mr. C. H. Purkis and Mr. W. J. Bennett within a short contribution, as it is full of theoretical aspects, exciting testing methods, and surprising practical facts. He would, therefore, confine himself to a few comments only.

The question of heat transmission through flue walls had been the object of many experiments by several investigators in the Gasinstitut. But the results were so scattered owing to the influences of changing local conditions, that they as yet did not dare to draw conclusions from what had been stated. The difficulty seemed to be that as the paper put it, the flow is neither laminar nor turbulent. Every connection of a new heater disturbed the pattern of the flow, sometimes for a long, sometimes for a short distance; and the temperature distribution across the flue varied. They had even tried to get rid of the influence of disturbances varying with the kind of appliance connected to the flue and had used a streamlined combustion chamber. But still they were not satisfied.

He would, therefore, like to support the statement that much work still remained to be done on this aspect of flues research and it should be done in as many places as possible. The removal of combustion products of gas appliances was the one thing which made gas more complicated than electricity. To do it safely and ever more easily and cheaply should be the aim of the gas industry all over the world.

LOCAL AUTHORITIES MAY NOW CREATE SMOKELESS ZONES

AS from December 31, certain provisions of the Clean Air Act came into operation. Laid before the Government by Mr. Duncan Sandys, the Minister of Housing and Local Government, the Order enables local authorities to create smoke control areas where the emission of smoke from buildings will be an offence. Local authorities are now able to create these areas by orders, which will have to be confirmed by the Minister.

Some other changes also came into force on December 31. All new furnaces, other than small domestic boilers, must be smokeless, so far as practicable. Notice of intention to install such a furnace will have to be given to the local authority. Then the Minister may make regulations requiring furnaces to be fitted with smoke density meters.

The height of new chimneys, other than those of houses, shops, and offices, will require approval by the local authority, and owners of colliery 'spoilbanks' must employ all practical means for preventing combustion of refuse and for minimising the emission of smoke and fumes from the surface.

From the end of this year local authorities may also make by-laws requiring the provision in new buildings of such arrangements for heating and cooking as are calculated to prevent, as far as possible, the emission of smoke.

A similar order has been made for Scotland. At a later date the remaining provisions of the Clean Air Act, which deal with the prohibition of dark smoke and the reduction of grit and dust from industry, will be brought into operation.

NATURAL GAS

The Standard Oil Company of New Jersey has announced that it will spend more than £446 mill. in 1957 on improving its facilities and searching for oil and natural gas.

Another interesting item of news about natural gas is contained in a recent report in *The Times*, which points out that this fuel is being used in the Toulouse area to overcome the petrol shortage. For many years quantities of natural gas have been extracted from deposits around St. Gaudens, south-west of Toulouse, but hitherto few motorists have made use of it because of its bulk.

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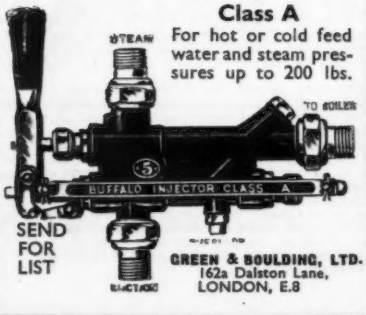

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EAST MIDLANDS GAS BOARD

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ASSISTANT DISTRICT MANAGER

APPLICATIONS are invited from suitably qualified persons for the appointment of Assistant District Manager to the Nottingham District which comprises 165,000 consumers.

The successful candidate will be responsible to the District Manager for all sales activities in showrooms and on the district, the control of gas fitting, stores and District clerical staff.

Applicants must possess administrative ability, a knowledge of sales promotion and gas fitting technique.

The salary will be on Senior Staff Salary Scale 'B,' £1,105-£1,265 per annum.

The successful applicant will be required to pass a medical examination and, unless already subject to a Pension Scheme by virtue of the Gas (Pension Rights) Regulations, 1950, will be required to join the Board's Staff Pension Scheme.

Applications, stating age and present position, and giving details of education, qualifications and experience, together with the names of two referees, should be addressed to reach the undersigned not later than January 19, 1957.

A. GWYNNE DAVIES,
Secretary.

East Midlands Gas Board,
Beverley House,
University Road,
Leicester.

December, 1956.

SCOTTISH GAS BOARD

STATISTICIAN:

APPLICATIONS are invited for a Statistician at Board Headquarters in Edinburgh. Applicants should be suitably qualified (University Degree with specialisation in Statistics or other appropriate qualification). Preference will be given to applicants with some commercial experience and knowledge of mechanical aids. The successful applicant will be responsible to the Chief Financial Officer for collection, analysis and interpretation of data throughout the Area. The salary for the appointment will be within the scale £1,025/£1,145 per annum. Applications stating age and giving particulars of education, training, experience and qualifications should be addressed to the undersigned within fourteen days of the appearance of this advertisement.

A. T. HERD,
Secretary.

26, Drumsheugh Gardens,
Edinburgh, 3.

December 26, 1956.

SCOTTISH GAS BOARD

NORTHERN DIVISION
STROMNESS DISTRICT

APPLICATIONS are invited from suitably experienced and qualified persons for the position of District Manager at Stromness.

The salary applicable to the post is in accordance with the Board's scale of salaries Provincial 'B' APT 6a (£625-£705) with house to rent.

The position is pensionable, and the successful applicant will be required to pass a medical examination.

Applications stating age, and giving particulars of education, training, experience and qualifications should be addressed to the undersigned to arrive not later than Monday, January 14, 1957.

H. S. MILNE,
Divisional Controller.

50, Cotton Street,
Aberdeen.

December 24, 1956.

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Applicants should have a sound knowledge of gas distribution engineering and should be experienced in the design and supervision of laying of bulk supply mains.

The position is superannuated and the successful applicant will be required to pass a Medical Examination.

Applications giving full particulars of age, qualifications and experience, together with copies of three recent testimonials, or names and addresses of three referees to whom reference can be made, to be lodged with the undersigned not later than Monday, January 28, 1957.

DAVID L. DICKSON,
Group Manager.

Gas Offices,
Grange Road,
Dunfermline.

December 29, 1956.

SCOTTISH GAS BOARD

DEPUTY SECRETARY

APPLICATIONS are invited from suitably qualified persons for the appointment of Deputy Secretary to the Board. Applicants should have considerable secretarial and administrative experience. The salary for the appointment will be within Group 'G' of the National Salaries Table for Senior Officers £1,850-£2,150 per annum with placing according to qualifications and experience.

The position is pensionable, and the successful applicant will be required to pass a medical examination.

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Applications stating age, and giving particulars of education, training and experience should be addressed to the undersigned to arrive not later than January 21, 1957.

S. C. JOHNSTONE,
District Manager.

Gas Works,
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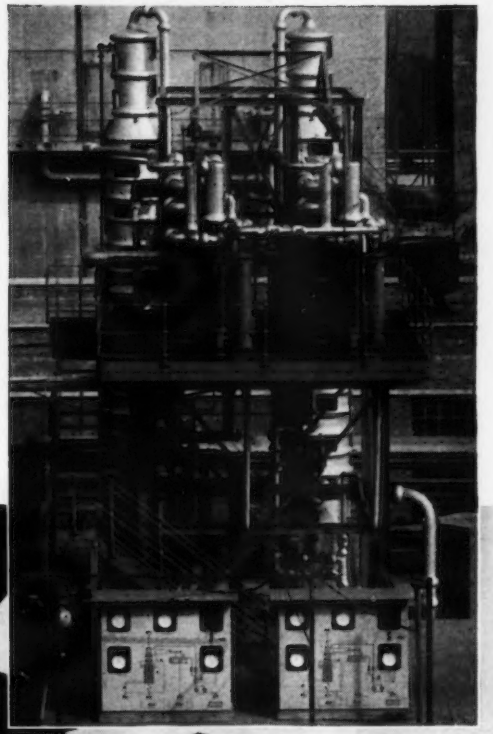

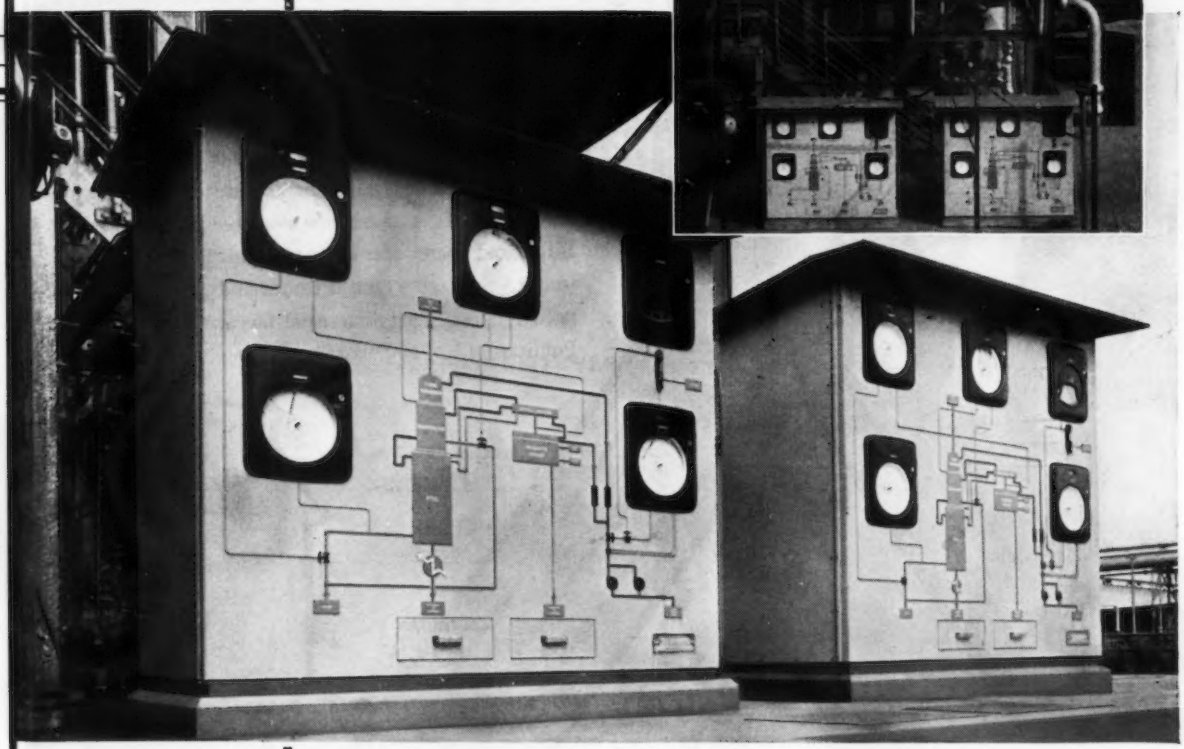

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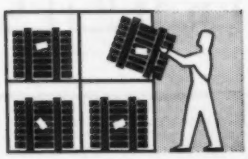

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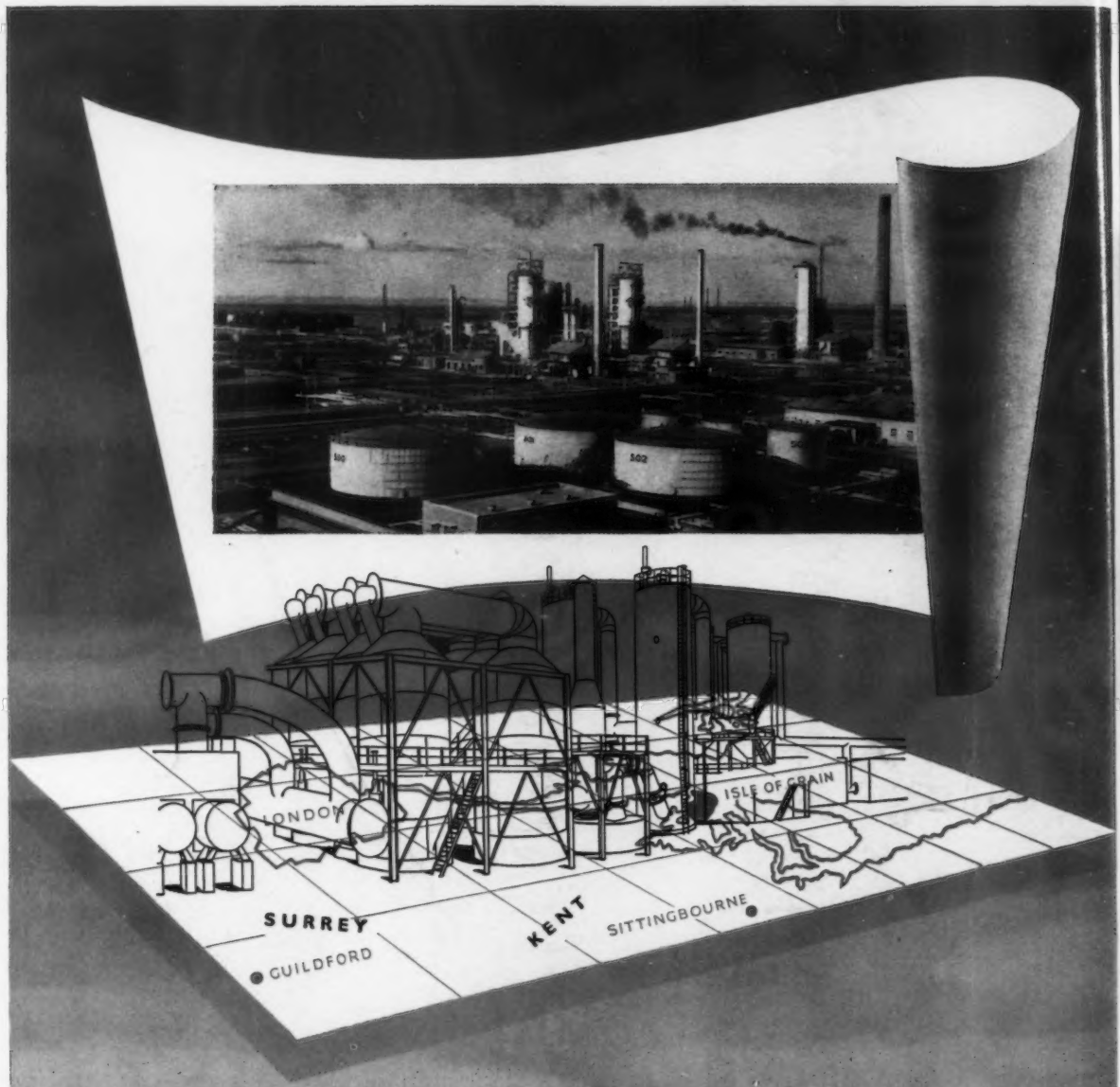

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